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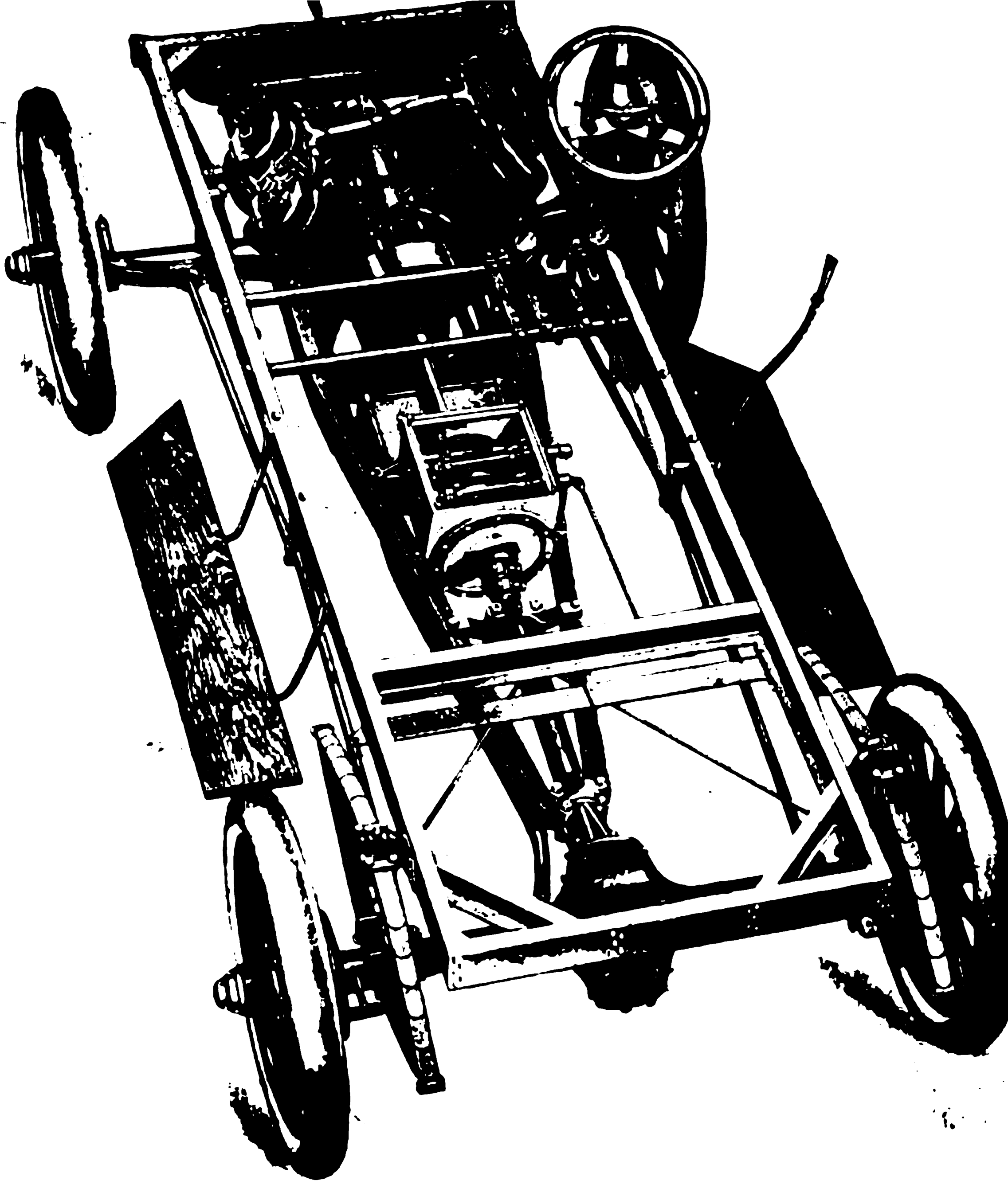

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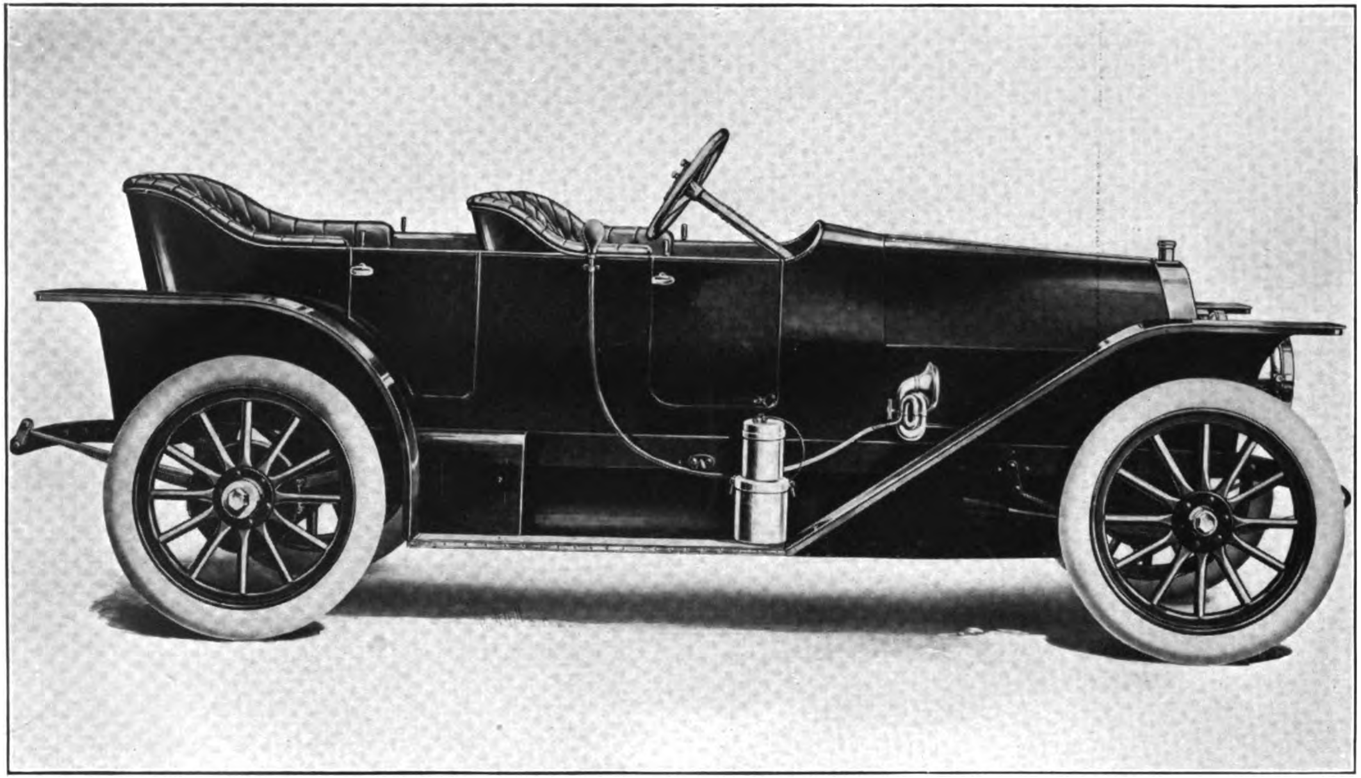

THE SPEEDWELL 50-HORSE-POWER TOURING CAR WITH TORPEDO BODY
The Speedwell Motor Car Co., Dayton, Ohio.

Amer. School of Correspondence. Chicago

Cyclopedia
of
Automobile Engineering

A General Reference Work on
THE CONSTRUCTION, OPERATION, AND CARE OF GASOLINE, STEAM, AND
ELECTRIC AUTOMOBILES, INSTRUCTION IN DRIVING, COMMERCIAL
VEHICLES, MOTORCYCLES, MOTOR BOATS, AERIAL VEHICLES,
SELF-PROPELLED RAILWAY CARS, ETC.

Prepared by a Staff of
AUTOMOBILE EXPERTS, CONSULTING ENGINEERS, AND DESIGNERS OF THE
HIGHEST PROFESSIONAL STANDING

Illustrated with over Two Thousand Engravings

FOUR VOLUMES

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Authors and Collaborators

CHARLES B. HAYWARD
Member, Society of Automobile Engineers
Formerly Secretary of the Society of Automobile Engineers
Formerly Engineering Editor, *The Automobile*

C. T. ZIEGLER
Automobile Engineer
Manager, Renault Frères Selling Branch, Chicago

HUGO DIEMER, M. E.
Professor of Mechanical Engineering, The Pennsylvania State College
American Society of Mechanical Engineers

HERBERT LADD TOWLE, B. A.
Consulting Engineer on Automobile and Gas Engine Work
Member, Society of Automobile Engineers
Formerly Associate Editor, *The Automobile*

S. E. REEDER
Cashier, Babcock Electric Carriage Co.

DARWIN S. HATCH, B. S.
Assistant Editor, Textbook Department, American School of Correspondence

MORRIS A. HALL, B. S.
Associate Editor, *The Automobile*
Associate Member, American Society of Mechanical Engineers

J. G. BAYERLINE
Vice-President and General Manager, Warren Motor-Car Company

GLENN M. HOBBS, Ph. D.
Secretary, American School of Correspondence

LIONEL S. MARKS, S. B., M. M. E.
Assistant Professor of Mechanical Engineering, Harvard University
American Society of Mechanical Engineers

Authors and Collaborators—Continued

LAWRENCE K. SAGER, S. B., M. P. L.
Patent Attorney and Electrical Expert
Formerly Assistant Examiner, U. S. Patent Office

ALFRED H. BARTSCH
Manager, N. S. U. Motor Co.

ROBERT ANDREWS MILLIKAN, Ph. D.
Associate Professor of Physics, University of Chicago

GEORGE L. LLOYD
Sales Manager, Velie Motor Vehicle Co.

PERCY H. THOMAS, S. B.
Of Thomas & Neall, Electrical Engineers, New York City
Formerly Chief Electrician, Cooper-Hewitt Electric Co.

WALTER G. MORSE
Treasurer, Atlas Motor-Car Company

ERNEST L. WALLACE, B. S.
Instructor in Electrical Engineering, American School of Correspondence
American Institute of Electrical Engineers

F. HALLETT LOVELL, JR.
President and Treasurer, Lovell-McConnell Manufacturing Co.

EDWARD B. WAITE
Head, Instruction Department, American School of Correspondence
American Society of Mechanical Engineers

G. G. LUTHY
Secretary and Advertising Manager, The Bartholomew Company

H. WILKINS PERRY
Manager, The Technical Press Bureau, New York City

HARRIS C. TROW, S. B., *Managing Editor*
Editor-in-Chief, Textbook Department, American School of Correspondence
American Institute of Electrical Engineers

Authorities Consulted

THE editors have freely consulted the standard technical literature of America and Europe in the preparation of these volumes. They desire to express their indebtedness, particularly, to the following eminent authorities, whose well-known treatises should be in the library of everyone interested in the Automobile and allied subjects.

Grateful acknowledgment is here made also for the invaluable co-operation of the foremost Automobile Firms and Manufacturers in making these volumes thoroughly representative of the very latest and best practice in the design, construction, and operation of Automobiles, Motorcycles, etc.; also for the valuable drawings, data, illustrations, suggestions, criticisms, and other courtesies.

CHARLES E. DURYEA

Consulting Engineer
First Vice-President, American Motor League
Member, American Motor-Car Manufacturers Association
Author of "Roadside Troubles"

❧

OCTAVE CHANUTE

Consulting Engineer
Past President of the American Society of Civil Engineers
Author of "Artificial Flight," etc.

❧

E. W. ROBERTS, M. E.

Member, American Society of Mechanical Engineers
Author of "Gas-Engine Handbook," "Gas Engines and Their Troubles," "The Automobile Pocket-Book," etc.

❧

BENJAMIN R. TILLSON

Director of H. J. Willard Company Automobile School
Author of "The Complete Automobile Instructor"

❧

SANFORD A. MOSS, M. S., Ph. D.

Member, American Society of Mechanical Engineers
Engineer, General Electric Co.
Author of "Elements of Gas Engine Design"

❧

GARDNER D. HISCOX, M. E.

Author of "Horseless Vehicles, Automobiles, and Motorcycles," "Gas, Gasoline, and Oil Engines," "Mechanical Movements, Powers, and Devices," etc.

❧

AUGUSTUS TREADWELL, Jr., E. E.

Associate Member, American Institute of Electrical Engineers
Author of "The Storage Battery; A Practical Treatise on the Construction, Theory, and Use of Secondary Batteries"

Authorities Consulted—Continued

THOMAS H. RUSSELL, M. E., LL. B.

Editor, *The American Cyclopedia of the Automobile*
Author of "Motor Boats," "History of the Automobile," "Automobile Driving, Self-Taught," "Automobile Motors and Mechanism," "Ignition Timing and Valve Setting," etc.

◆

CHARLES EDWARD LUCKE, Ph. D.

Mechanical Engineering Department, Columbia University
Author of "Gas Engine Design"

◆

VICTOR LOUGHEED

Member of the Aeronautic Society
Founder of the Society of Automobile Engineers
Formerly Editor, *Motor*
Author of "Some Trends of Automobile Design," "How to Drive an Automobile," and "Vehicles of the Air"

◆

R. P. HEARNE

Author of "Air Ships in Peace and War," and "Motoring"

◆

H. DIEDERICHS, M. E.

Professor of Experimental Engineering, Sibley College, Cornell University
Author of "Internal Combustion Engineering"

◆

JOHN HENRY KNIGHT

Author of "Light Motor Cars and Voiturettes," "Motor Repairing for Amateurs," etc.

◆

WM. ROBINSON, M. E.

Professor of Mechanical and Electrical Engineering in University College, Nottingham
Author of "Gas and Petroleum Engines"

◆

W. POYNTER ADAMS

Member of the Institution of Automobile Engineers
Author of "Motor-Car Mechanisms and Management"

◆

ROLLA C. CARPENTER, M. M. E., LL. D.

Professor of Experimental Engineering, Sibley College, Cornell University
Author of "Internal Combustion Engines"

◆

ROGER B. WHITMAN

Technical Director, The New York School of Automobile Engineers
Author of "Motor-Car Principles"

Authorities Consulted—Continued

CHARLES P. ROOT

Formerly Editor, *Motor Age*
Author of "Automobile Troubles, and How to Remedy Them"

◆

W. HILBERT

Associate Member, Institute of Electrical Engineers
Author of "Electric Ignition for Motor Vehicles"

◆

SIR HIRAM MAXIM

Member, American Society of Civil Engineers
British Association for the Advancement of Science
Chevalier Légion d' Honneur
Author of "Artificial and Natural Flight," etc.

◆

SIGMUND KRAUSZ

Author of "Complete Automobile Record," "A B C of Motoring"

◆

JOHN GEDDES McINTOSH

Lecturer on Manufacture and Application of Industrial Alcohol at the Polytechnic Institute, London
Author of "Industrial Alcohol," etc.

◆

FREDERICK GROVER, A. M., Inst. C. E., M. I. Mech. E.

Consulting Engineer
Author of "Modern Gas and Oil Engines"

◆

FRANCIS B. CROCKER, M. E., Ph. D.

Head of Department of Electrical Engineering, Columbia University
Past-President, American Institute of Electrical Engineers
Author of "Electric Lighting;" Joint Author of "Management of Electrical Machinery"

◆

A. HILDEBRANDT

Captain and Instructor in the Prussian Aeronautic Corps
Author of "Airships Past and Present"

◆

T. HYLER WHITE

Associate Member, Institute of Mechanical Engineers
Author of "Petrol Motors and Motor Cars"

Authorities Consulted—Continued

ROBERT H. THURSTON, C. E., Ph. B., A. M., LL. D.
Director of Sibley College, Cornell University
Author of "Manual of the Steam Engine," "Manual of Steam Boilers," etc

MAX PEMBERTON
Motoring Editor, *The London Sphere*
Author of "The Amateur Motorist"

HERMAN W. L. MOEDEBECK
Major and Battalions Kommandeur in Badischen Fussartillerie
Author of "Pocket-book of Aeronautics"

EDWARD F. MILLER
Professor of Steam Engineering, Massachusetts Institute of Technology
Author of "Steam Boilers"

ALBERT L. CLOUGH
Author of "Operation, Care, and Repair of Automobiles"

W. F. DURAND
Author of "Motor Boats," etc.

PAUL N. HASLUCK
Editor, *Work*, and *Building World*
Author of "Motorcycle Building"

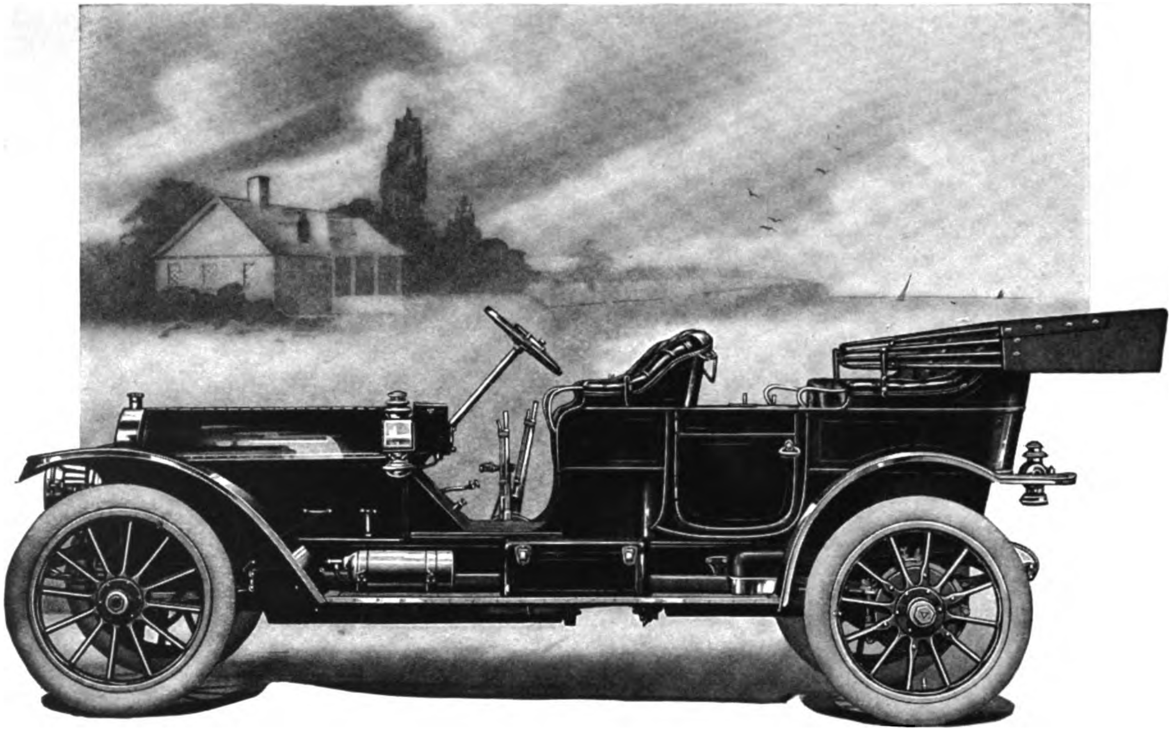
JAMES E. HOMANS, A. M.
Author of "Self-Propelled Vehicles"

R. J. MECREDY
Editor, *The Encyclopedia of Motoring*, *Motor News*, etc.

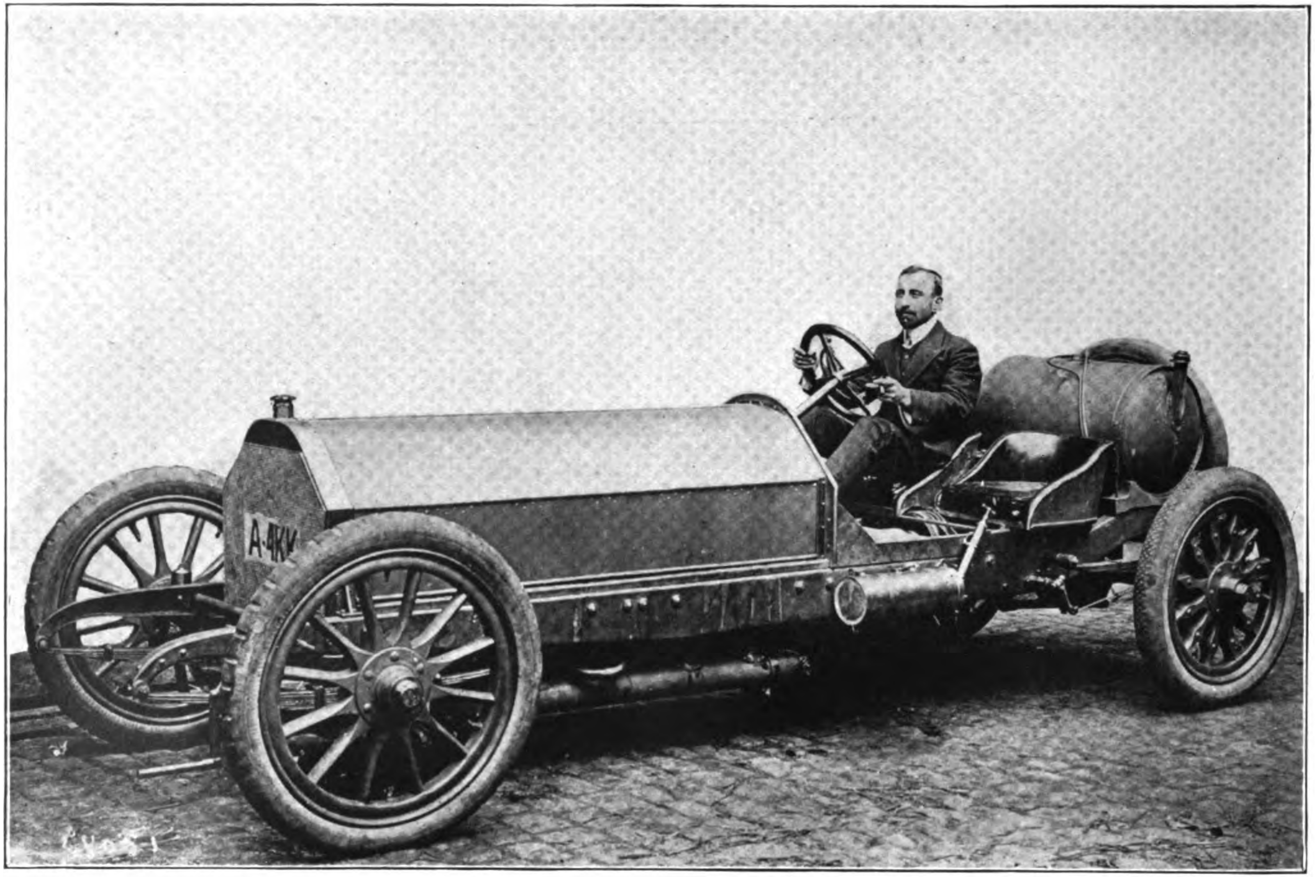
L. ELLIOTT BROOKES
Author of "The Automobile Handbook"

S. R. BOTTONE
Author of "Ignition Devices," "Magnetos for Automobiles," etc.

LAMAR LYNDON, B. E., M. E.
Consulting Electrical Engineer
Associate Member, American Institute of Electrical Engineers
Author of "Storage Battery Engineering"



STEVENS-DURYEA TOURING CAR WITH STANDARD EQUIPMENT
Stevens-Duryea Co., Chicopee Falls, Mass.



DESIGNER WEIGEL DRIVING THE 100-HORSE-POWER WEIGEL BUILT BY HIS FIRM (ENGLISH) FOR THE *Grand Prix de France*

Foreword

WITHIN recent years the internal-combustion motor and the self-propelled vehicle have become such important factors in the evolution of industrial, commercial, and social life, that a distinct need has been created for an authoritative work of reference embodying the results and methods of the latest approved practice in the construction, care, and operation of the various types of motor cars and other vehicles driven by gas, steam, and electricity, and in allied branches of this rapidly developing field of apparently unlimited possibilities. It is the purpose of the Cyclopedia of Automobile Engineering to fill this acknowledged need.

¶ The application of the internal-combustion motor, the steam generator, the storage battery and electric motor, to the development of types of mechanically propelled road carriages and motor boats, is a far-reaching engineering problem of great difficulty. The same is true of the airship motor and the application of the gas engine to the development of efficient and economical methods of power production for aërial navigation. While not all details of these problems have as yet been finally worked out or reduced to standard practice, sufficient progress has been made to assure results of permanent value. In so far as these results are embodied in the constructions used in typical modern cars, they are presented in these pages without any attempt at great refinement of engineering subtleties, but with all explanation of details essential to a working knowledge.

¶ Special stress is laid on the practical as distinguished from the merely theoretical or descriptive form of treatment, so that these volumes will be found especially adapted for purposes of self-instruction. They are designed not only to meet the requirements of instruction for the novice, but also to serve as a reference work replete with information and suggestions of the utmost practical value to the most experienced chauffeur and engineer.

¶ The method adopted in the preparation of the Cyclopedia of Automobile Engineering is that which the American School of Correspondence has developed and employed so successfully for many years. It is not an experiment, but has stood the severest of all tests — that of practical use — which has demonstrated it to be the best method yet devised for the education of the busy man.

¶ For purposes of ready reference and timely information so frequently needed in automobile operation and construction, it is believed that these volumes will be found to meet every requirement.

¶ Grateful acknowledgment is due the corps of authors and collaborators — engineers of wide practical experience, and teachers of well-recognized ability — without whose co-operation this work would have been impossible.

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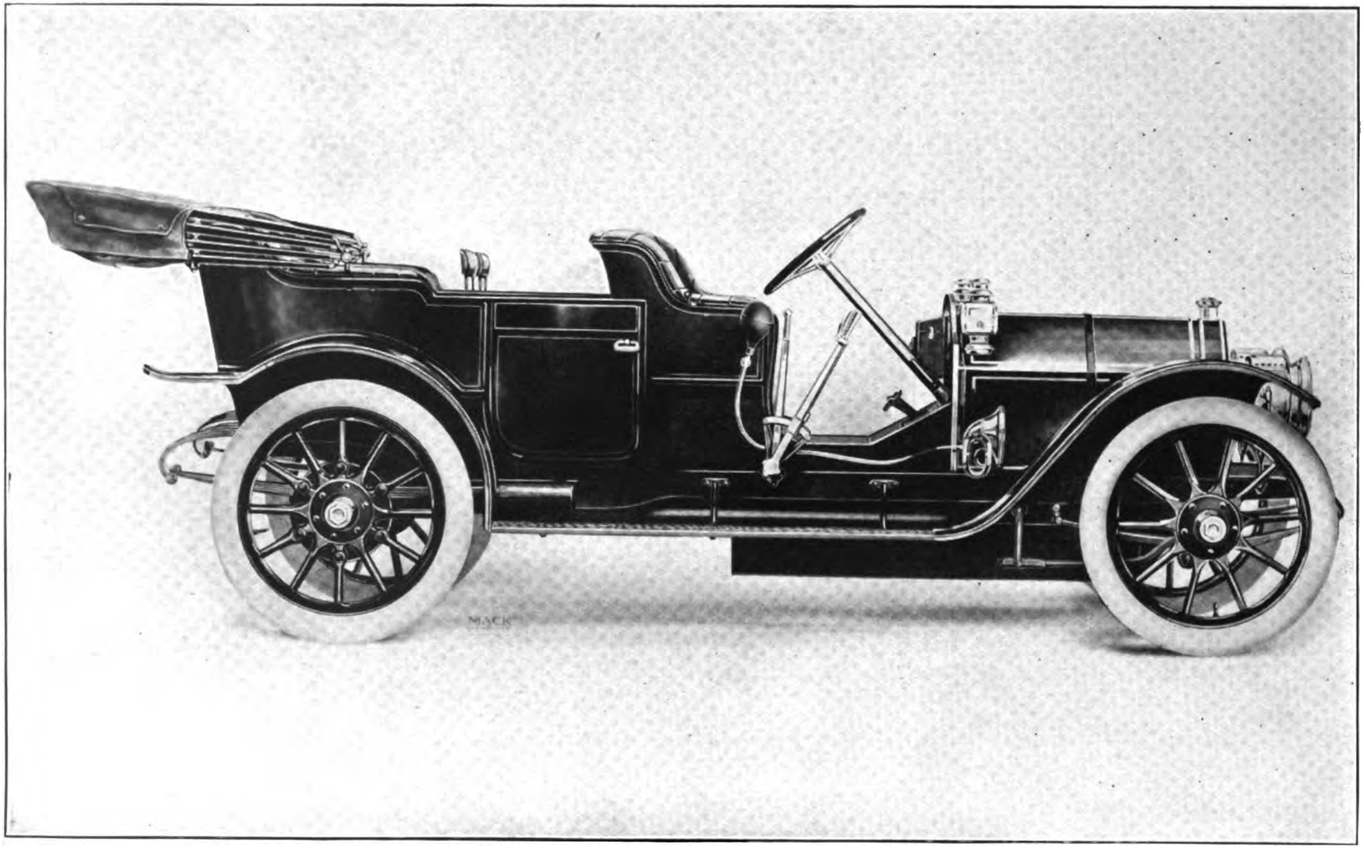


CHALMERS "FORTY" TOURING CAR
The Chalmers Motor Car Co., Detroit, Mich.

AUTOMOBILES

PART I

In attempting to study the operation and function of the various parts constituting the automobile, the best plan is, first, to analyze the machine into its distinct groups of parts, and then to determine the function of each part in each group.

COMPONENT PARTS OF A MOTOR-CAR

The essential parts of the automobile may be broadly classified under three main heads—namely:

(a) The Running Gear;
(b) The Power Plant;
(c) The Body, its Accessories and Fittings.

THE RUNNING GEAR

The running gear (Fig. 1) consists of: *Wheels* (*A*), for supporting and propelling the whole machine; *Tires* (*B*), for cushioning the car from rough shocks and jars, and for providing a sufficient adhesion of the wheels to the roadway to insure the friction necessary for propulsion when the wheels are rotated; *Axles* (*C*), to carry the wheels and maintain them in correct relative position; *Springs* (*D*), to eliminate more completely the shocks and jars; *Frame* (*E*), to which all the above parts of the vehicle are attached in the best possible

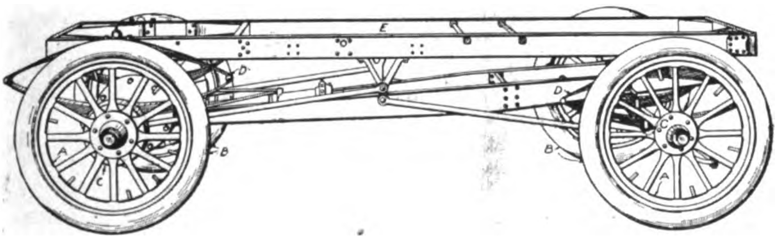


Fig. 1. Running Gear of a Motor-Car.
A—Wheels; *B*—Tires; *C*—Axles; *D*—Springs; *E*—Frame.

location, such frame being capable of sustaining the loads to be carried. In addition to the above features shown in Fig. 1, the running gear (see Fig. 2) includes *steering devices* (controlled by hand-wheel, shown at upper right), for altering the direction of movement of the vehicle; *equalizing mechanism* or *differentials* (generally housed, as shown at center of rear axle), for permitting one driving wheel to turn faster than the other when the machine is turning a curve; *change-speed devices* (ordinarily controlled by hand-lever, shown between front and rear wheels at right), for altering the speed

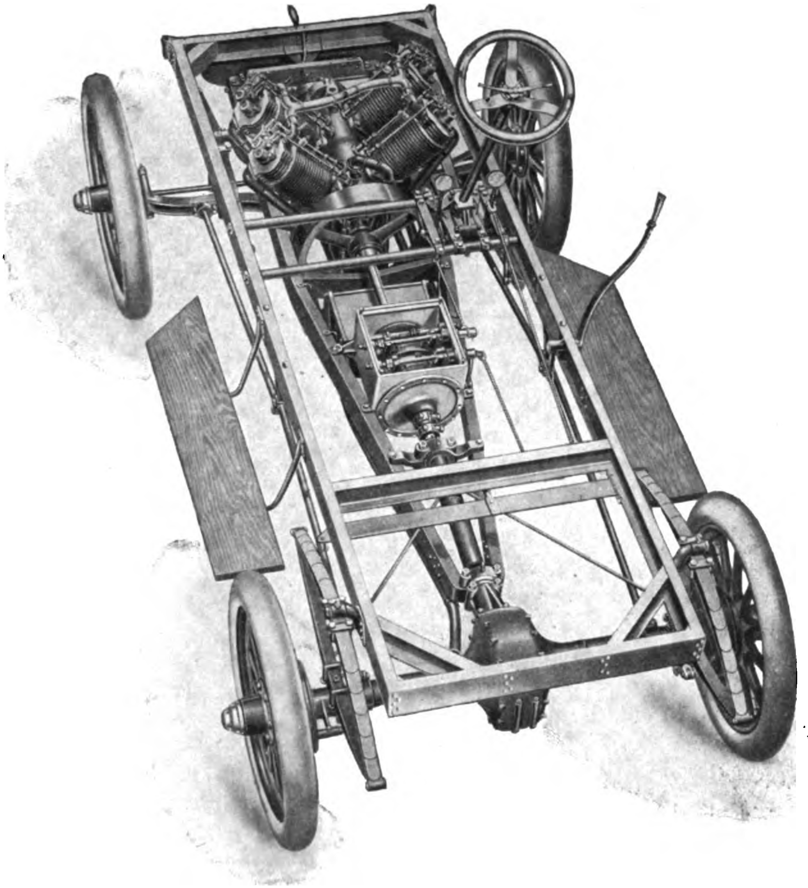


Fig. 2. Typical Chassis of a Motor-Car, Showing Running Gear and Power Plant. Nordyke & Marmon Company, Indianapolis, Ind.

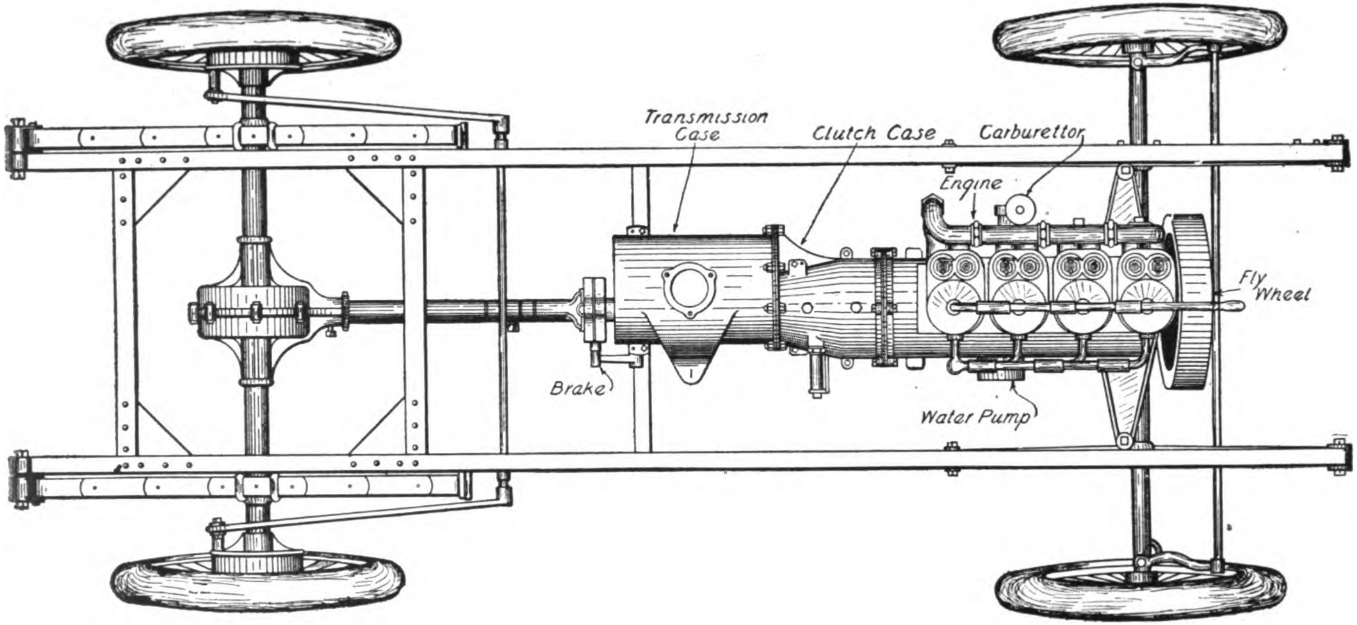


Fig. 3. Power Plant of a Gasoline-Driven Car.
Stevens-Duryea Company, Chicopee Falls, Mass.

of the vehicle while that of the engine may be left unchanged; and *brakes* (ordinarily operated by foot-levers, shown under steering wheel), for bringing the vehicle to a gradual or immediate stop.

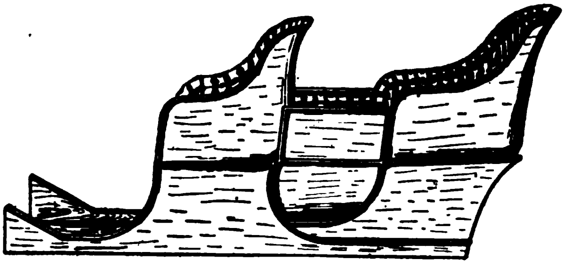


Fig. 4. Wood Body.

Power Plant. The power plant, in the case of the gasoline-driven car, consists of the *Engine, Fly-Wheel, Carbureter, Clutch, Transmission,* and *Water-Pump,* as shown in Fig. 3. In addition to these parts, the power plant of the gasoline-driven car includes: *Batteries, Spark-Coils, Spark-Plugs, Oiling Devices,* and other features discussed in detail as to their operation under subsequent headings. The power plants of steam-driven and electrically driven cars are also described in detail in chapters devoted to these types.

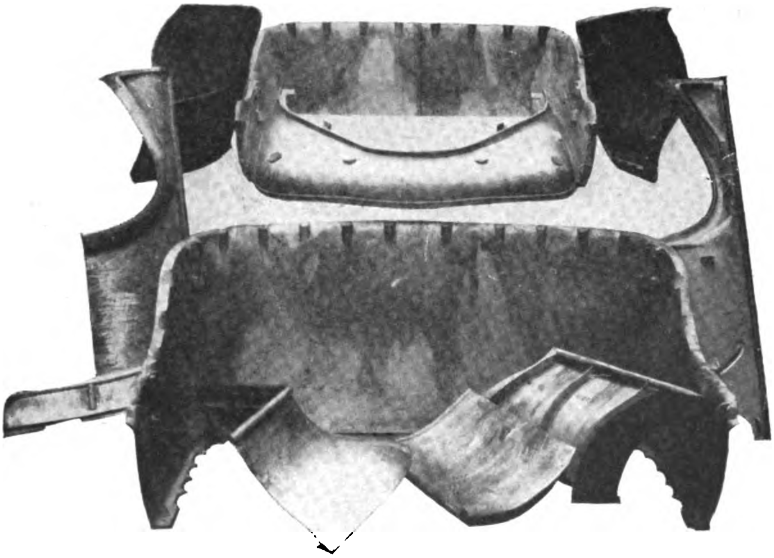


Fig. 5. Component Parts of an Aluminum Body.
Nordyke & Marmon Company, Indianapolis, Ind.

Body. The body may be either of wood, of pressed steel, or of cast aluminum. The various styles of bodies are classified and described later.

As to materials, solid wood or veneered wood bodies (Fig. 4) are both liable to cracking and warping, due to exposure to the weather. The pressed-steel body is liable to dents. Aluminum bodies (Fig. 5) are usually cast in separate pieces, and finished with wood seats. Taken all in all, the cast aluminum body is best. It is not usually furnished, however, in the cheaper types of car at present.

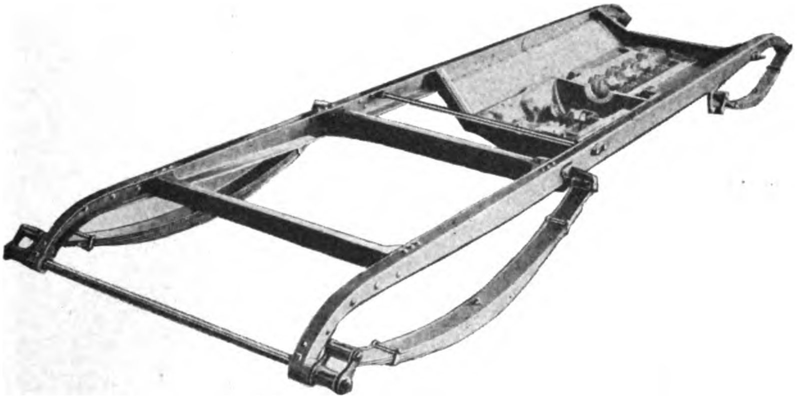


Fig. 6. Pressed-Steel Frame, with Pressed-Steel Motor and Gear Case Support which Acts as Bracing at Weakest Part of Frame.
Corbin Motor Vehicle Corporation, New Britain, Conn.

The Frame. Pressed steel is to-day practically the universal material for automobile frames. The name "pressed steel" arises from the fact that the steel is cut from sheets which are placed between dies and forced into shape by heavy presses. This pressing is always done while the steel is cold, since, if the metal were heated, it could not be maintained at a uniform temperature in the presses, and would warp. Moreover, the scale would have to be removed for the sake of good appearance of the frame.

Fig. 6 shows a pressed-steel frame as constructed by the Corbin Motor Vehicle Corporation, New Britain, Conn. A feature of this frame is the formed sheet-metal pan, of heavy gauge, which is riveted to the side and cross-members of the frame proper, and to which the flanged motor and gear cases are bolted. This construction makes the front part of the frame practically an I-beam section laid flat, and largely eliminates the tendency to sag or settle. It must be remembered, from the very fact that the frame material is ductile enough to have permitted of its being pressed cold without cracking, that in the very nature of things it can have no real springiness, and repeated shocks and bounces will cause it gradually to settle. This settling will occur at the weakest part of the frame, and is usually not over one-eighth of an inch—hardly enough to be noticed with the eye; but it is enough to affect any mechanism that depends on the frame to maintain perfect alignment of parts. Troubles with bearings in engines and transmissions can often be traced to this source.

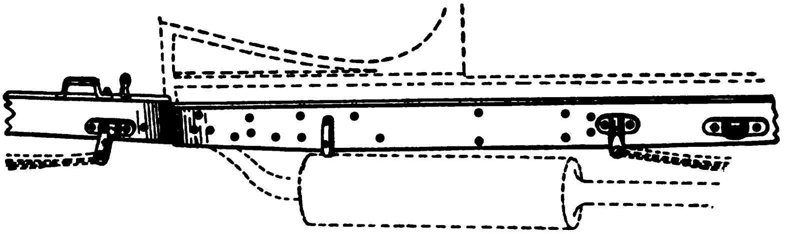


Fig. 7. Side Bar of Frame, Showing Excessive Riveting.

Theoretically the best material to resist this sagging tendency is steel, wood-filled. The trouble with wood filling, however, is that hot riveting cannot be done, and cold riveting is likely to split the pressed-steel frame; so, in actual practice, the wood-filled frame has almost disappeared.

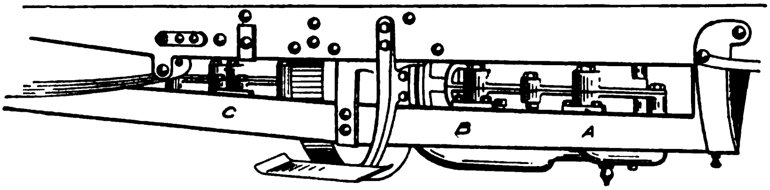


Fig. 8. Frame Weakened by Excessive Riveting in Parts Subjected to Heaviest Weight.

Fig. 7 shows a side bar of a typical four-cylinder car, in which altogether too many rivet-holes have been punched or drilled.

Fig. 8 shows a frame construction in which the strain tending to produce sagging has been allowed to come at points of the frame which have already been weakened by rivet-holes. Both of these constructions are faulty, and should be avoided.

Fig. 9 shows a type of motor suspension which does away with the drop frame, and is designed for a minimum number of rivet-holes. The motor frame is suspended at points 1, 2, and 3, points 1 and 2 being side lugs, and 3 being a cross-bar. This type of suspension is employed by the Stevens-Duryea Company of Chicopee Falls, Mass. It should be noted that the points of suspension are three. A three-point suspension of the motor is preferable to a four-point, for the reason that any lateral distortion produces an undue strain at one of the four points in the latter type of suspension, while in a three-point suspension the strain is equally distributed.

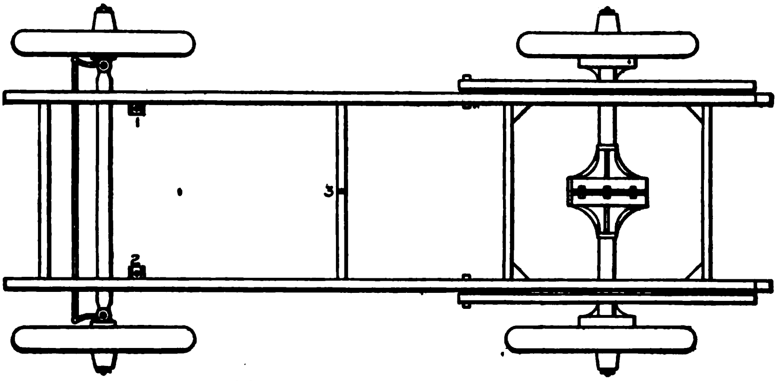


Fig. 9. Three-Point Motor Suspension.
Stevens-Duryea Company, Chicopee Falls, Mass.

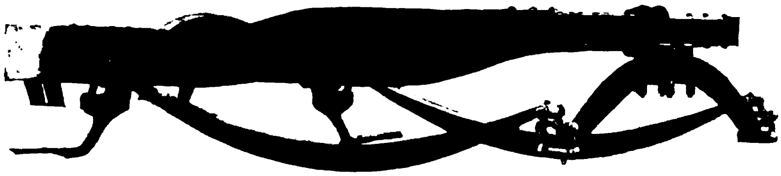


Fig. 10. Rear Spring Suspension.
Peerless Motor Car Company, Cleveland, Ohio.

Spring-Hangers. The spring-hangers are drop forgings closely fitting into the ends of the pressed-steel frame, as seen in Fig. 6. They must be of sufficient length not to unduly strain the frame, and must be hot-riveted to the frame.

Springs. Intermediate between the frame and the axles are the springs. These are attached to the spring-hangers by means of *spring links,* and rest on surfaces called *spring seats* on the axles.

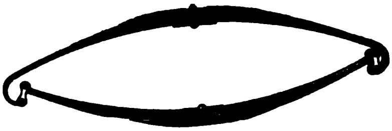


Fig. 11. Full Elliptical Spring. Reliance Motor Car Company, Detroit, Mich.

Fig. 10 shows the rear spring suspension employed by the Peerless Motor Car Company of Cleveland, Ohio. The springs shown are what are designated as *semi-elliptical springs,* with eight leaves. Formerly springs were used as short as 34 inches, but the tendency is toward longer springs, 44 inches being not an uncommon length. Fig. 10 also illustrates what is called the *drop* type of frame construction, the frame drop-

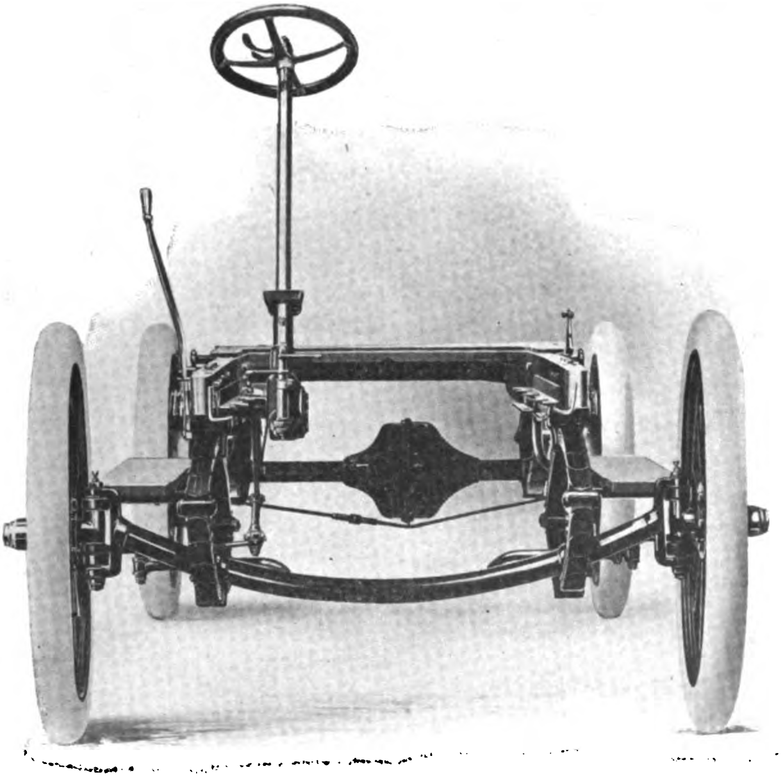


Fig. 12. Front View, Franklin Spring Suspension, Showing Tubular Front Axle. H. H. Franklin Manufacturing Company, Syracuse, N. Y.

ping down between the wheels so as to carry the passengers nearer the ground and thus lower the center of gravity of the loaded car.

Fig. 11 shows a *full elliptic spring*, with five leaves. This type of spring is used on the lighter types of cars, but has been largely superseded by the semi-elliptical in heavier cars.

Front Axles. Front axles have developed from the solid type with steering yoke part of the same forging, to the tubular type with drop center and with the steering yoke drop-forged and brazed onto the main axle tube The tubes employed are seamless, of 2 to 2½ inches diameter, with ¼-inch walls. However, the uncertainty of workmanship in connection with brazing has resulted in a tendency toward the I-beam type of front axle, in which the steering yoke is part of the same piece, as is also the spring seat.

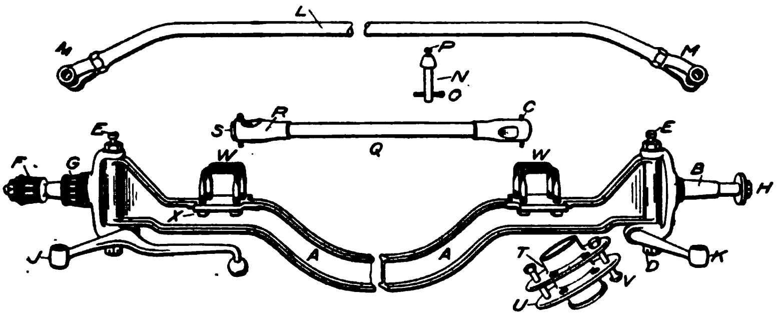


Fig. 13. I-Beam Type of Front Axle, with Parts Making Up Front-Axle System, as Used in Frayer-Miller Cars.
A—Axle; *B*—Knuckle; *C*—Pins; *D*—Nuts; *E*—Oiler; *F*, *G*—Roller Bearings (Timken); *H*—Nut; *J*, *K*—Steering Arms; *L*—Cross-Rod; *M*—Yokes; *N*—Pins; *O*—Cotters; *P*—Oiler; *Q*—Fore and Aft Connecting Tube; *R*—Ball Joint; *S*—Nut; *T*—Front Hub; U—Flange; *V*—Bolts; *W*—Spring Clips; *X*—Nuts.
Oscar [illegible] Automobile Company, Columbus, Ohio.

Fig. 12 shows the tubular type of front axle as employed in the Franklin motor-car. Fig. 13 shows the I-beam type of axle, together with a list of detail parts which go to make up the assembled front axle, as used in the Frayer-Miller car.

Rear Axles. Rear axles are mostly of the *live* or *rotating* type. A few cars which use the double-chain drive employ a *non-rotating* or *dead* rear axle—that is, one on which the wheels turn, while the axle itself does not turn with the wheels. This type of axle is considerably used on commercial trucks.

For touring cars and passenger cars generally, the tendency in America has been towards the *live* axle, usually made in halves, each

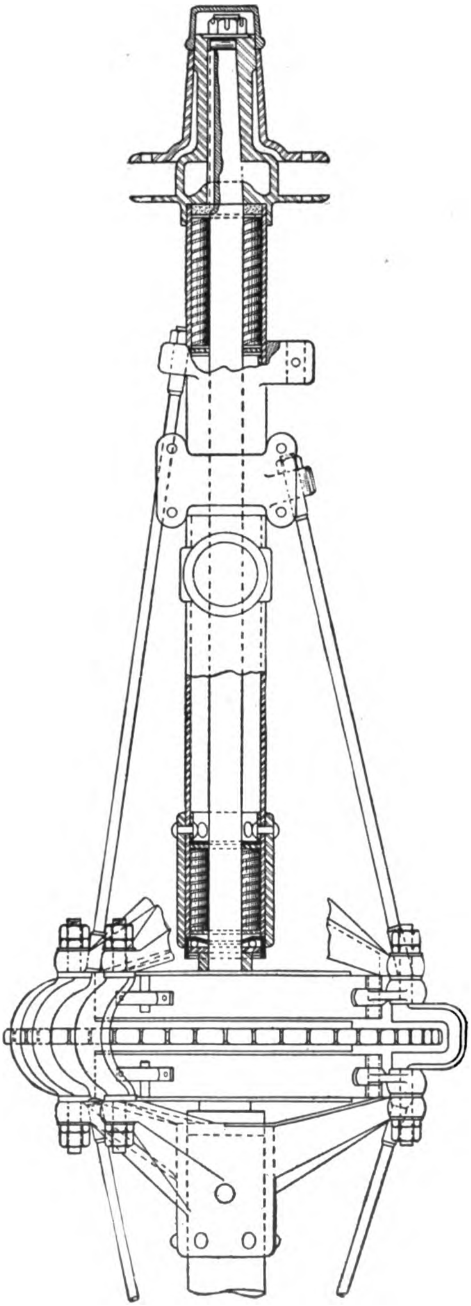


Fig. 14. Live Rear Axle, Halves Meeting at Differential. Chain-Driven, as Used in Cadillac Automobile, Detroit, Mich. Hyatt Roller Bearing Company, Harrison, N. J.

half driven from a centrally located differential gear set. The construction and operation of differential gears is more fully taken up later under the heading of "Power Transmission."

Fig. 14 shows a *chain-driven* rear axle, the axle being in two halves. The rear wheels are keyed onto each half of the live axle, which rotates in roller bearings. The illustration shows the axle used by the Cadillac Automobile Company.

Fig. 15 shows the axle construction used on Reo cars.

Fig. 16 shows a *shaft-drive* rear axle of the live type, the wheels rotating with the axle.

Fig. 17 shows what is known as the *clutch-drive* or *floating* type of live axle. In this type the rear wheels do not rotate on and with the live axle-halves, but, as seen in the cut, they rotate on the dead

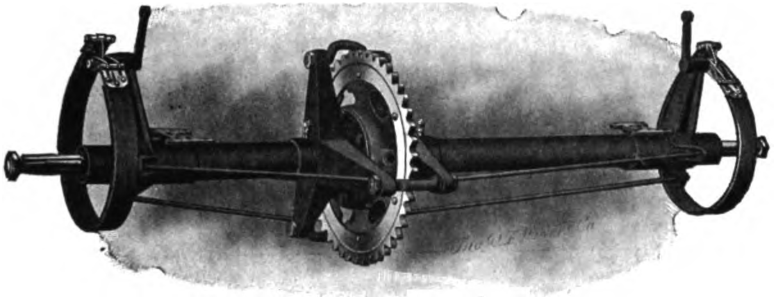


Fig. 15. Axle Construction on Reo Cars.
Reo Motor Car Company, Lansing, Mich.

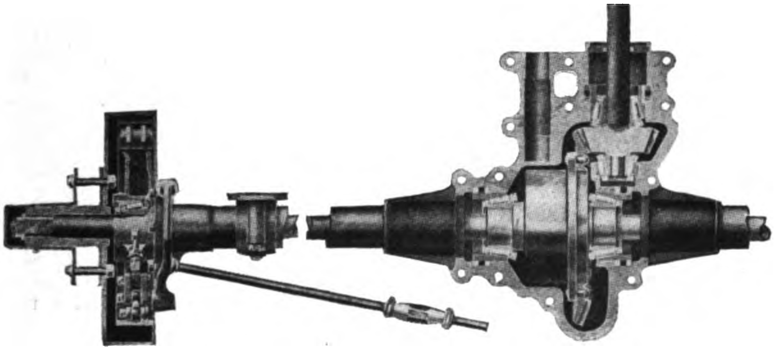


Fig. 16. Shaft-Drive Rear Axle, Rear Vertical View at Left, Horizontal View at Right.
Timken Roller Bearing Axle Company, Canton, Ohio.

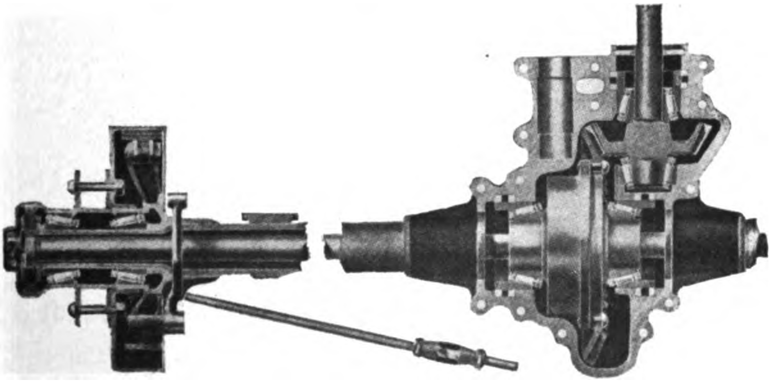


Fig. 17. Clutch-Drive or Floating Type Rear Axle, Rear Vertical View at Left, Horizontal View at Right.
Timken Roller Bearing Axle Company, Canton, Ohio.

outer casings of the axle, without being connected to it except through the dog-clutch, which is kept in position by the hub-cap. In this type the axle tubes carry the weight of the car and of the wheels.

Rear-axle tubing should be not less than 2 inches in diameter; some cars use as large as 3 inches in diameter. The tubing should be reinforced by a strut, as shown in the cuts.

Steering Yoke, Neck, and Knuckle. The front axle terminates at either end in the *steering yoke*. In the tubular type of front axle, the steering yokes are usually brazed into the axle tube. The I-beam type of front axle usually has the yoke part of the I-beam piece, thus making the axle and steering yoke all in one piece, securing a better construction.

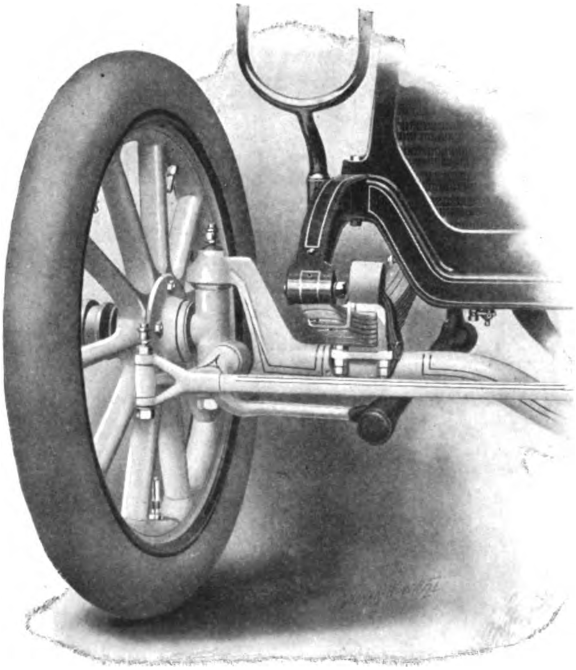


Fig. 18. Steering Yoke, Neck, and Knuckle.
Packard Motor Car Company, Detroit, Mich.

Fig. 18 shows the tubular type of axle, together with steering yoke, neck, and knuckle, as employed by the Packard Motor Car Company, of Detroit, Mich. The yoke, it will be seen, carries the vertical steering spindle or *neck*. The latter, in turn, supports the wheel, and is also attached to the *steering knuckle*.

Fig. 19 shows a detail of steering knuckle as used in the Rambler car built by Thos. B. Jeffery & Company, Kenosha, Wis. The load is carried on the thrust-bearing shown in section under the upper arm of the steering yoke. This bearing comprises two hardened tool-steel plates and a row of thirteen $\frac{3}{8}$-inch steel balls. The center pin is tapered from $1\frac{1}{8}$ inches at the top to $\frac{7}{8}$ inch at the bottom. At each end is a nut bearing against the yoke, whereby the position of the taper pin within this bearing in the knuckle may be adjusted. To adjust it, the nut at the upper end must be loosened, and the one at the lower end tightened. This will draw the taper downward into its seat in the knuckle. If too tight, release the lower nut and screw down the upper one. When properly adjusted, tighten both nuts.

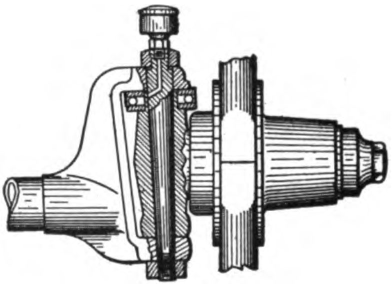


Fig. 19. Detail of Steering Knuckle, Rambler Car.
Thomas B. Jeffery & Co., Kenosha, Wis.

The ball thrust-bearing is usually packed in hard grease, and will require very little attention. The center pin is provided with an oil-cup which feeds through a vent as indicated, into the bearing of the pin.

Fig. 20. Steering Mechanism of the Cartercar.
Motor Car Company, Detroit, Mich.

Steering Connections. The two steering knuckles are connected by a rod known as the *transverse rod* or *cross-rod*, so that they will move in unison. This rod is shown in Fig. 20, as used in the Cartercar, built by the Motor Car Company, Detroit, Mich.

The vertical steering spindle or neck, in addition to carrying the wheel bearing, in the case of the right-hand spindle is usually made so as to form also in one piece the steering arm. This construction is shown in Fig. 21, as used by the Timken Roller Bearing Axle Company, Canton, Ohio. It will be noticed that the steering arm terminates in a round ball. This ball is part of a ball-and-socket joint connecting the steering arm, through a reach-rod, to the sector shaft of the steering column.

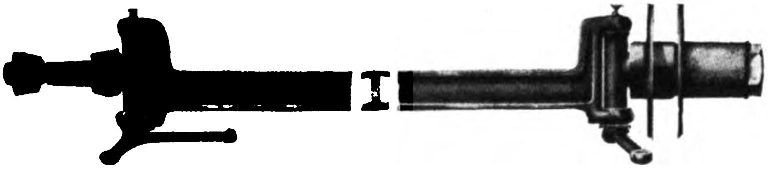


Fig. 21. Steering Arm, Showing Ball Joint.
Timken Roller Bearing Axle Company, Canton, Ohio.

Fig. 22 shows the reach-rod as used in the Oldsmobile, made by the Olds Motor Works, Lansing, Mich. The socket part of the ball-and-socket joint is usually composed of two hollowed-out bronze blocks adjustable for wear.

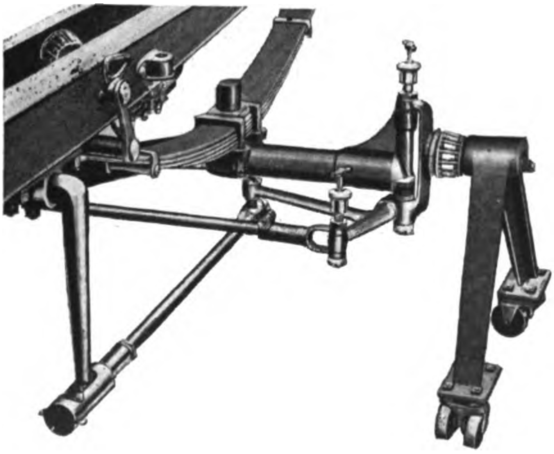


Fig. 22. Steering Connections of Oldsmobile.
Olds Motor Works, Lansing, Mich.

Steering Gear. Cars are almost universally steered by means of a large-diameter hand-wheel on the top of a considerably inclined tubular steering post or column. The steering wheel is usually made of a solid three-arm brass ring, covered with black walnut or cherry and given a natural wood finish. The steering column is made of heavy steel tubing with brass tube outside, the outer casing serving for a standard or support. The innermost tube is the one usually used for steering purposes. Concentric with the steering tube, and surrounding it, there are frequently placed other tubes which serve other purposes—in connection with spark and throttle control.

The steering wheel's motion is transmitted through the innermost tube, to a screw or worm, which in turn meshes with a nut or gear or sector of a gear, operating a bell-crank connected with the steering arm.

The screw and split or adjustable nut type of construction is claimed to be less liable to have back-lash than the worm-and-gear type, as in the former all back-lash due to wear may be readily taken up.

Fig. 23 shows a steering column of the screw and nut type as used by the Knox Automobile Company, Springfield, Mass. The screw is integral with the column, and is cut from the solid bar. The nut is exceptionally long, and is formed of hard babbitt, finished to exactly fit the quintuple thread; and has a formed space on one side fitting a corresponding block upon the cap, thus preventing the nut from turning. The bell-crank in this part is of nickel-steel. Fig. 24 shows a detail of the nut and bell-crank in this same column.

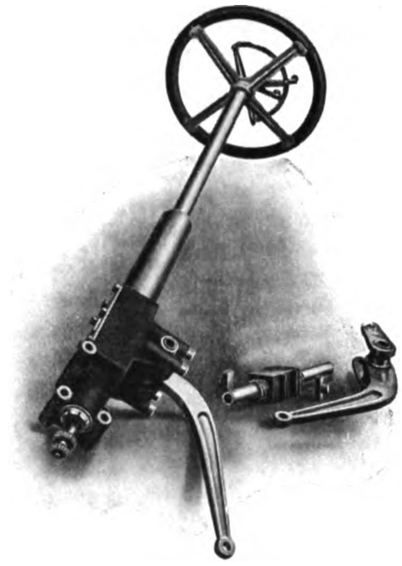


Fig. 23. Steering Column of Screw and Nut Type.
Knox Automobile Company, Springfield, Mass.

The steering mechanism of an automobile is subjected to more severe stresses and heavy vibratory strains than any other part, and a break in the steering gear is almost certain to result in a dangerous accident. Hence the need for most liberal dimensions and superfine quality of material, and for extreme care in construction of all parts connected with the steering system.

Fig. 25 shows the worm-and-gear type of steering gear as used by the Peerless Motor Car Company, of Cleveland, Ohio. This type is found used about as frequently as the screw and nut type; and if the gears are perfectly cut, truly adjusted, and made of best material, there should be no perceptible wear. In the gearing system shown in the illustration, the worm is located at the base of the steering column proper. When the hand-wheel is turned, this turns a gear. A shaft is forged with this gear, to which is attached an arm operating the connecting-rod to the steering knuckles. Around the shaft, where it protrudes through the gear casing, is an eccentric bushing graduated by thirty-seconds of an inch, which may be moved to take up any lost motion in the steering wheel. Moving this bushing so that the widest part is away from the steering column, forces the gear into closer mesh with the worm. Moving this bushing a quarter of an inch at the most, should be enough to take up any wear. Should any of the teeth become worn, disconnect the arm from gear to connecting-rod, and five complete turns of the steering hand-wheel will give a new set of teeth on the gear. Thrust-bearings with $\frac{3}{8}$-inch balls are placed above and below the gear on the steering column, and are self-seating; and the worm is adjusted for end play by screwing down an adjusting nut at top of casing.

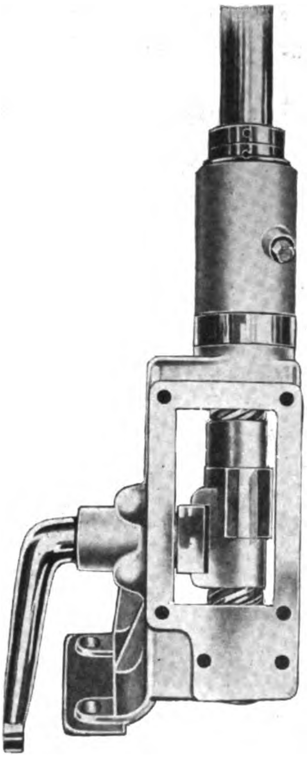
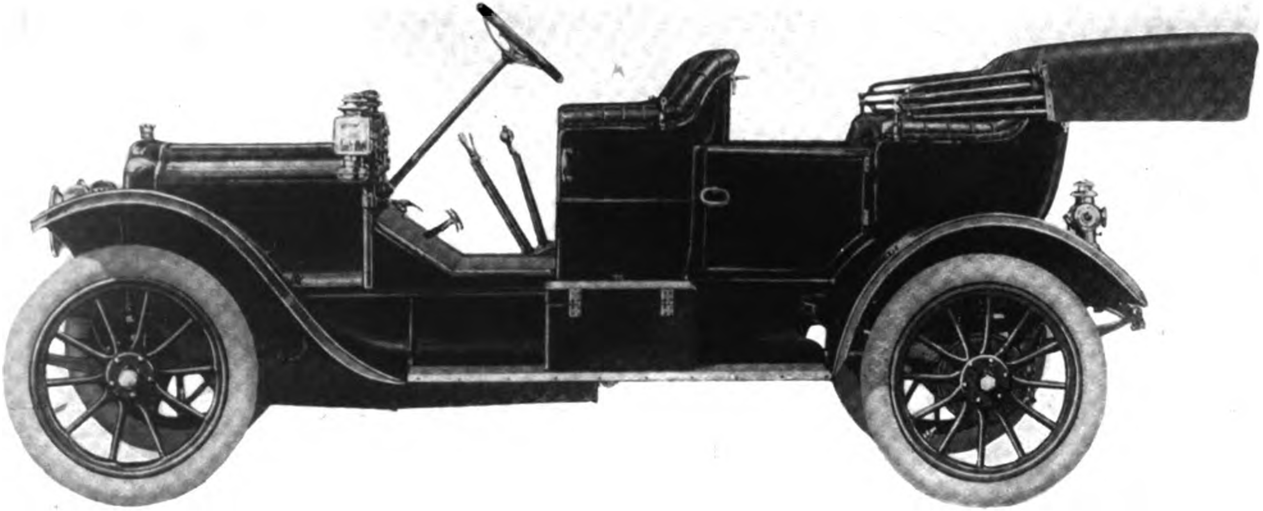


Fig. 24. Detail of Nut and Bell-Crank in Screw and Nut Type of Steering Gear.
Knox Automobile Company, Springfield, Mass.

The more usual form is to use simply a sector of a gear, instead of a whole gear. This type of construction is shown in Fig. 26, as used by the Corbin Motor Vehicle Corporation, of New Britain, Conn. The form shown is a worm and sector cut by the Hindley patented process. By this process, every tooth in the worm is in contact with, and for the full width of, the sector face. The steering case is of Parsons manganese bronze, and all minor parts of the steering system are made of high-class steel forgings.



WHITE MODEL GA, GASOLINE CAR
Forty Horse-Power.

THE POWER PLANT

The power plant of an automobile includes the prime mover and all the accessories necessary to start it and keep it in continuous motion. In the case of the electrically driven automobile, the power plant includes the batteries, rheostat, motor, and other details which will be described under the heading of Electrically Driven Cars. In the case of steam-propelled automobiles, the power plant includes the boiler, engine, heating outfit, and accessories as described under the heading of Steam-Driven Cars. In the case of the gasoline-driven car, the power plant naturally groups itself as follows:

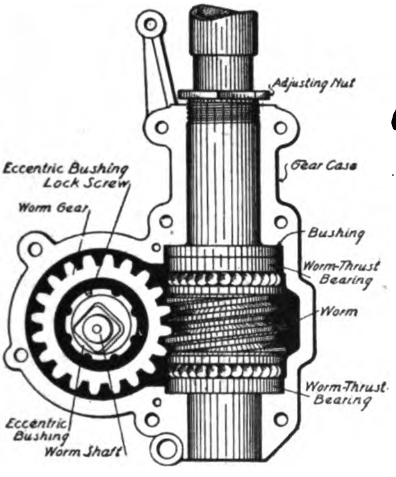


Fig. 25. Worm-and-Gear Type of Steering Gear.
Peerless Motor Car Company, Cleveland, Ohio.

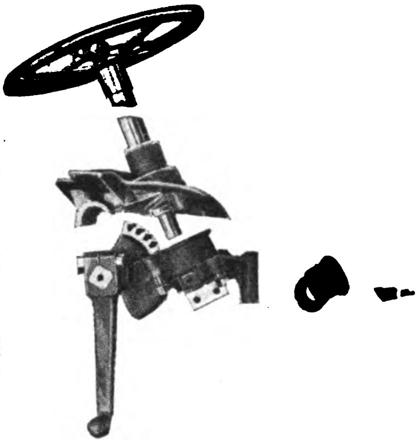


Fig. 26. Worm and Sector Type of Steering Gear.
Corbin Motor Vehicle Corporation, New Britain, Conn.

1. The engine proper, consisting of the reciprocating parts, the rotating parts, the cylinders, the crank-case, and the valves.
2. The fuel system, consisting of the gasoline tank and its connections through the carbureter to and from the engine.
3. The ignition system, consisting of the batteries, the spark-coils, the magneto or dynamo, the commutator, and the spark-plugs.
4. The cooling system, consisting of the fan, and, in water-cooled engines, also of the water tank, the water pump or siphon, the radiator, and interconnecting parts.
5. The lubricating system of the motor.

The Gas-Engine Cycle. The gas-engine cycle consists of four distinct steps—namely:

1. Admission of the charge of explosive fuel.
2. The compression of this charge.
3. The ignition or explosion of this charge.
4. Exhaust or expulsion of the burnt charge.

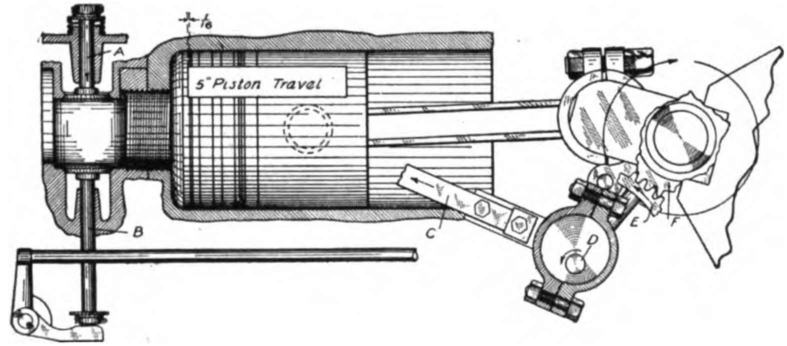


Fig. 27. Beginning of Suction or First Stroke in a Four-Cycle Engine.
Cadillac Motor Car Company, Detroit, Mich.

If the complete process as above requires four strokes of the piston-rod in any one cylinder, the engine is designated as a *four-cycle engine,* although a more exact designation would be to call it a *four-stroke cycle.* If the complete process is accomplished in two strokes of the piston, the engine is designated as a *two-cycle engine.*

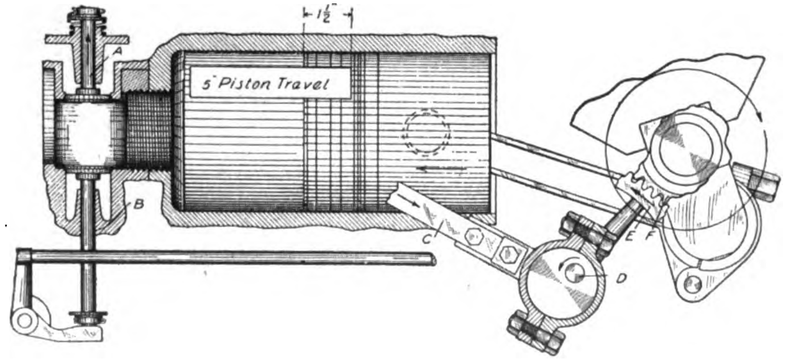


Fig. 28. Beginning of Second or Compression Stroke in a Four-Cycle Engine.
Cadillac Motor Car Company, Detroit, Mich.

Figs. 27, 28, 29, and 30 show the positions of piston and valves during these four steps, as they take place in the Cadillac single-cylinder four-cycle engine.

Fig. 27 shows the beginning of the first or suction stroke of the cycle. At $\frac{1}{16}$ inch past the dead center or end of the stroke, the inlet valve *A* commences to open, which allows the vapor supplied by the carbureter to be drawn into the cylinder, the motor running as indicated by the arrows. During this stroke the exhaust valve *B* is closed. The inlet valve *A* is opened by the eccentric rod *C*, its movement being controlled by the eccentric on the secondary shaft *D*. This shaft is driven at one-half the speed of the motor by the two-to-one gear *E* and pinion *F*.

Fig. 28 shows the beginning of the second or compression stroke at the closing point of the inlet valve, both valves being closed during this stroke. The piston, traveling as indicated by the arrow, compresses the charge to a pressure of about 60 pounds, and the compressed charge is ignited at or before the end of this stroke by a spark taking place in the *spark-plug* (the action of which will be explained in the discussion of Ignition Systems), the force of the explosion driving the piston forward to the position shown in Fig. 29.

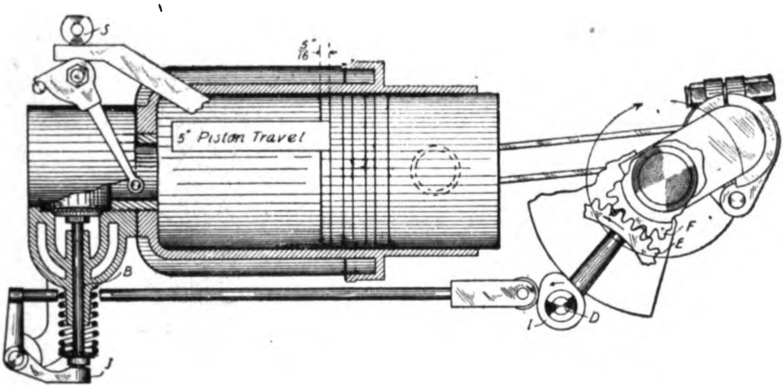


Fig. 29. End of Working or Third Stroke in a Four-Cycle Engine. Cadillac Motor Car Company, Detroit, Mich.

During these two strokes—namely, the compression and working strokes—both valves, if correctly timed, should be completely closed.

Fig. 29 illustrates the end of the working stroke or third stroke of the cycle, where the exhaust valve commences to open $\frac{5}{16}$ inch from the end of the stroke, or slightly previous to dead center.

During the fourth or exhaust stroke, the gases are expelled from the cylinder through the valve *B*. The exhaust valve *B* is operated by the cam *I*, which pushes the exhaust rocker arm *J* and lifts the exhaust valve *B*.

Fig. 30 shows the position when the exhaust valve *B* has just closed $\frac{1}{32}$ inch of the stroke past dead center. The inlet valve *A* will open $\frac{1}{32}$ inch later, admitting new vapor, as in Fig. 27.

Two-Cycle Engines. In two-cycle engines the crank-case is used to admit the charge while the piston is on the upward stroke.

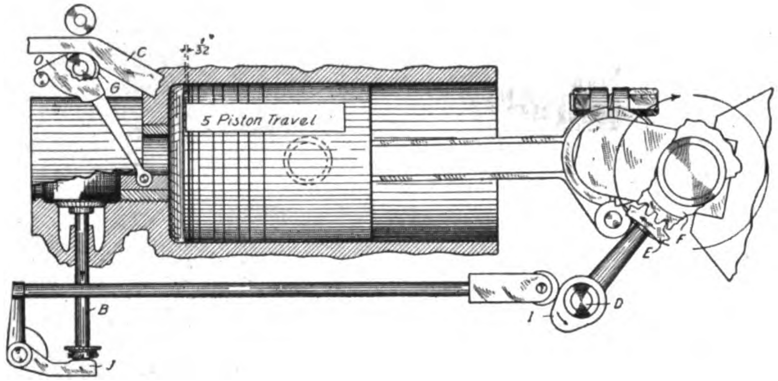


Fig. 30. End of Fourth or Exhaust Stroke in a Four-Cycle Engine.
Cadillac Motor Car Company, Detroit, Mich.

On the working or downward stroke of the piston, the vapor in the crank-case is forced through a by-pass, by the descending piston, this by-pass admitting it into the upper part of the cylinder, where it is compressed into small volume and ignited at the proper time.

In the two-cycle engine the process of exhausting the burnt gases and admitting the new charge are both performed during a single downward stroke, the exhaust port being uncovered first by the piston and allowing the greater part of the burnt gases to escape before the inlet port is opened. Hence, in the two-cycle engine, an impulse is received with each revolution of the fly-wheel and main shaft; in the four-cycle engine an impulse is received every fourth stroke or every other revolution of the fly-wheel and crank-shaft.

The two-cycle engine offers strong talking points, since all mechanically operated valves are replaced by mere port-holes, which results in greater mechanical efficiency. Moreover, the more frequent working impulses should result in a constant torque and much smoother running. Two-cycle engines have been in use quite generally on motor-boats. The engines of the two-cycle type built for marine work have always shown considerable irregularity in running; and it has been the general impression that the operations of charging, compressing, firing, and exhausting cannot be properly accomplished during one revolution. However, it may be that, just as the air-cooled engine is gaining greatly in favor, though several years ago not considered equal to the water-cooled type, so a similar change in favor of the two-cycle engine may be brought about as this type of engine is perfected. There are several cars now on the market, notable among them being the Elmore and the Jewel, which are showing up very favorably with two-cycle engines.

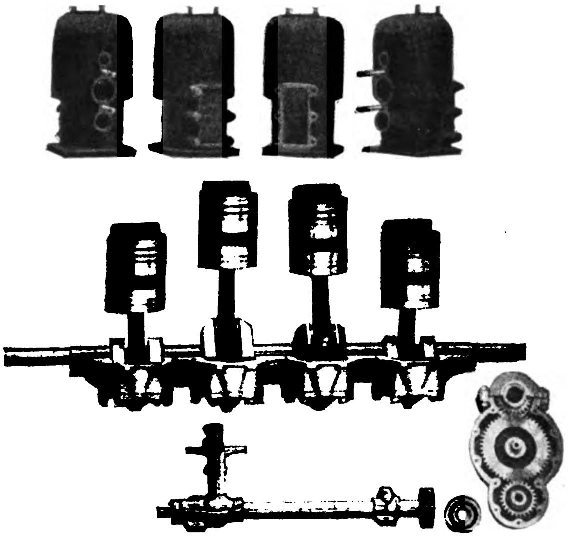


Fig. 31. Working Parts of Elmore 4-Cylinder 2-Cycle Motor, Showing Small Number of Parts.
Elmore Manufacturing Company, Clyde, Ohio.

Fig. 31 shows the working parts of the Elmore valveless two-cycle engine. Each cylinder on a four-cycle engine has more parts than all of the cylinders here shown.

Working Parts of Engine. It is essential that every automobile operator should be familiar with the names of the working parts of the engine.

As the single-cylinder engines such as used in the Reo, the Oldsmobile, the Cadillac, and other well-known runabouts, are easier to list in detail than multiple-cylinder engines, a typical example of a single-cylinder engine, showing parts in detail, is given in Fig. 32.

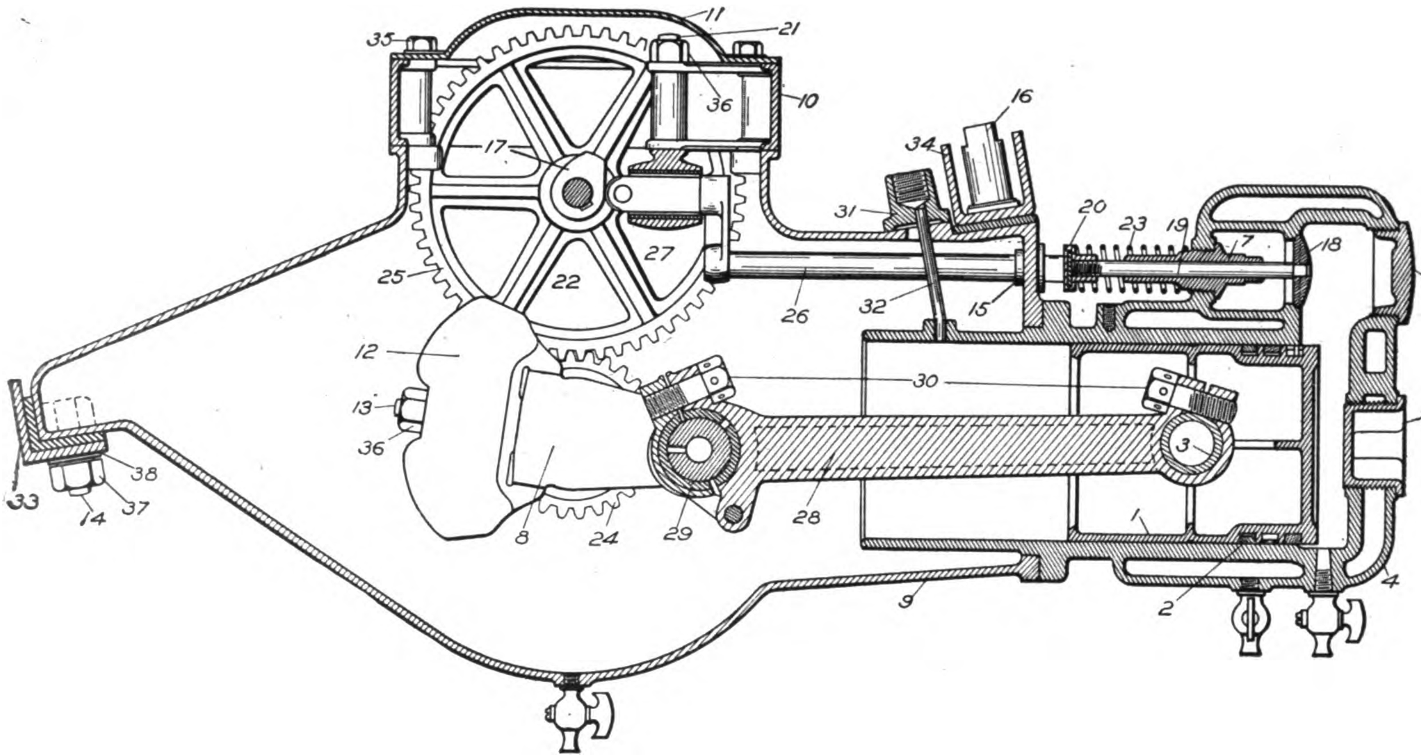


Fig. 32. Diagram Showing Detailed Parts of Single-Cylinder Engine as Used in the Reo Car. Reo Motor Car Company, Lansing, Mich.
1—Piston; 2—Piston-Ring; 3—Piston Pin; 4—Cylinder; 5—Valve-Cover; 6—Water-Jacket Plug; 7—Valve-Stem Guide; 8—Crank-Shaft; 9—Crank-Case; 10—Crank-Case Valve Box; 11—Crank-Case Valve Box Cover; 12—Counterweights; 13—Counterweights Stud; 14—Stud Crank-Case to Frame; 15—Valve-Rod Bushing; 16—Nut for Crank-Case Stud; 17—Exhaust Cam; 18—Valve; 19—Valve Stem; 20—Valve-Stem Head; 21—Valve-Rod Bearing; 22—Valve Roller; 23—Exhaust Valve Spring; 24—Small Cam Gear; 25—Large Cam Gear; 26—Valve-Rod; 27—Valve-Rod Head; 28—Connecting Rod; 29—Connecting-Rod Cap; 30—Connecting-Rod Bolt; 31—Oil-Cup Support; 32—Cylinder Oil Tube; 33—Rear Engine Support; 34—Front Engine Support; 35—Hexagon Nut, 5/16-Inch; 36—Hexagon Nut, ½-Inch; 37—Hexagon Nut ⅝-Inch; 38—Spring Washer, ⅝-Inch.

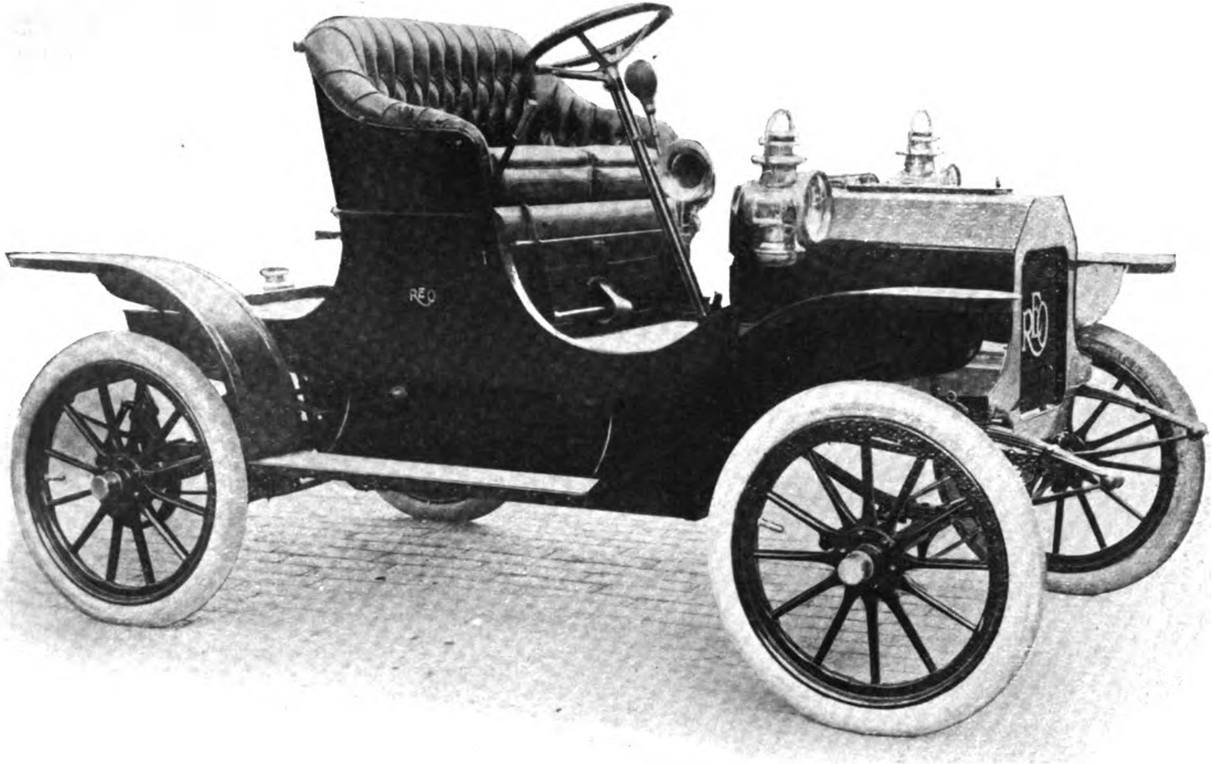


Fig. 32A. Reo Single-Cylinder Runabout. Reo Motor Car Company, Lansing, Mich.

Single- and Multiple-Cylinder Engines. The *single-cylinder* engine is of necessity the type of engine used on the lowest-priced cars. It has the advantage of simplicity; and when it comes to a choice between a high-grade, relatively high-priced single-cylinder engine car and a multiple-cylinder car with a cheaply built engine, there can be but one choice, and that in favor of the high-grade single-cylinder engine, as, in the other alternative of cheaper cylinders and more of them, one buys only more trouble.

The single-cylinder engine, having only one working imp

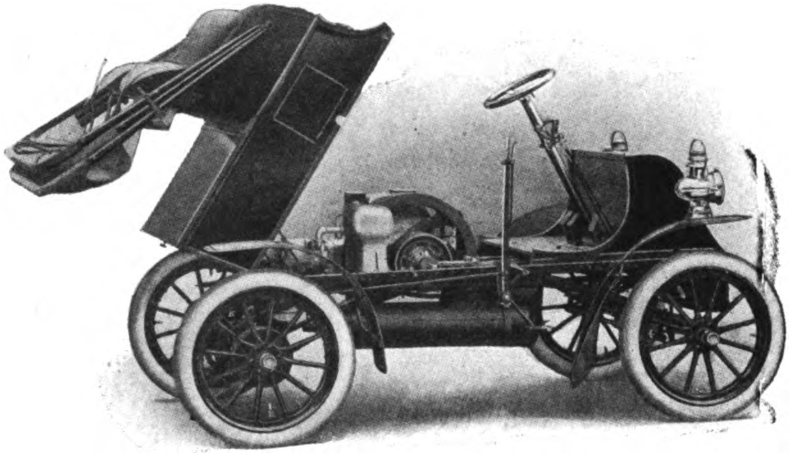


Fig. 33. One-Cylinder Engine as Used in Hewitt Motor-Car.
Hewitt Motor Company, New York, N. Y.

for every two revolutions, requires a fly-wheel of heavier weight and larger diameter than is used in the multiple-cylinder engines.

Fig. 33 shows a well-proportioned one-cylinder engine, as used by the Hewitt Motor Company, New York City.

In the single-cylinder construction, even with the very best engine, the vibration is decidedly noticeable when the engine is slowed down under load, as when climbing a hill.

The *two-cylinder opposed type* of construction gives a very good balancing of reciprocating parts. Fig. 34 shows this type of engine as used in the Reo touring car. The motor runs in the same direction as the car, and causes no sidewise vibration, which adds materially to the life of the car. The original two-cylinder opposed cars placed the engine under the body, many of them having the engine crosswise of the car, thus causing undue vibration, besides having the engine in an inaccessible position. Most modern cars with a capacity of twelve to twenty horse-power, place the two-cylinder engine under the hood, but keep the engine in a horizontal position.

For powers over twenty horse-power, the four-cylinder engine is in almost universal use. The construction of the engine in Fig. 35 is what is known as the *separately cast cylinder type* of engine. Another type of four-cylinder construction, and one quite generally used, is the *cast-in-pair* type. The latter construction takes up less room, giving a more compact motor, making possible a shorter hood, and also giving less weight. On the other hand, by casting each cylinder separately, it is possible to have a bearing between each crank, thus giving greater bearing surface, lessening the strains on the crank-shaft, and increasing the life of the bearings. Moreover, should one cylinder be burnt out or cracked, in the separately cast cylinder type this would mean the loss of but one cylinder, while in the cast-in-pair type it would mean the loss of the pair of cylinders. On the whole, the greater advantage lies with the separately cast construction.

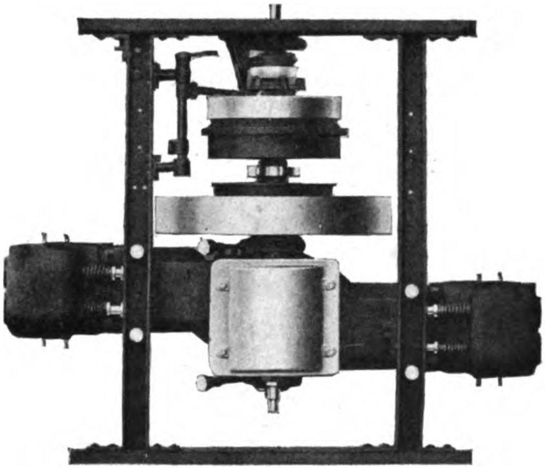


Fig. 34. Two-Cylinder Opposed Engine of Reo Car. Reo Motor Car Company, Lansing, Mich.

Principal Engine Parts; Material and Workmanship. The proper material for water-cooled gas-engine cylinders is a fine-grained gray iron mixture. Several makers of high-grade engines anneal the cylinders after they are bored, and grind them to gauge after annealing. This method of machining has been found to reduce to a minimum the liability to distortion of the cylinder under the temperature strains to which it is subjected.

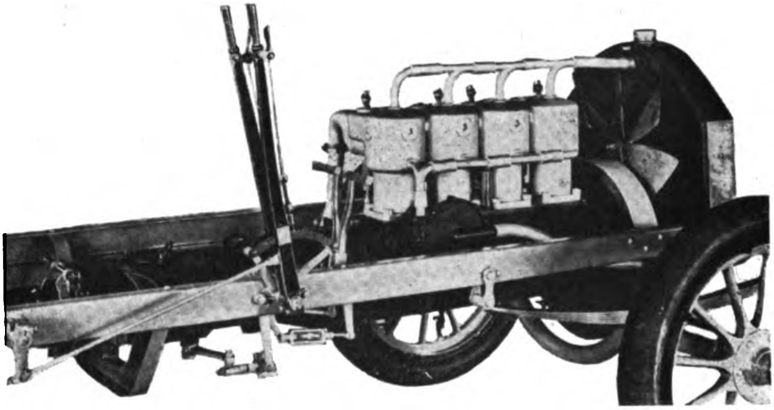


Fig. 35. Four-Cylinder Vertical Engine with Fly-Wheel in Front. Stevens-Duryea Company, Chicopee Falls, Mass.

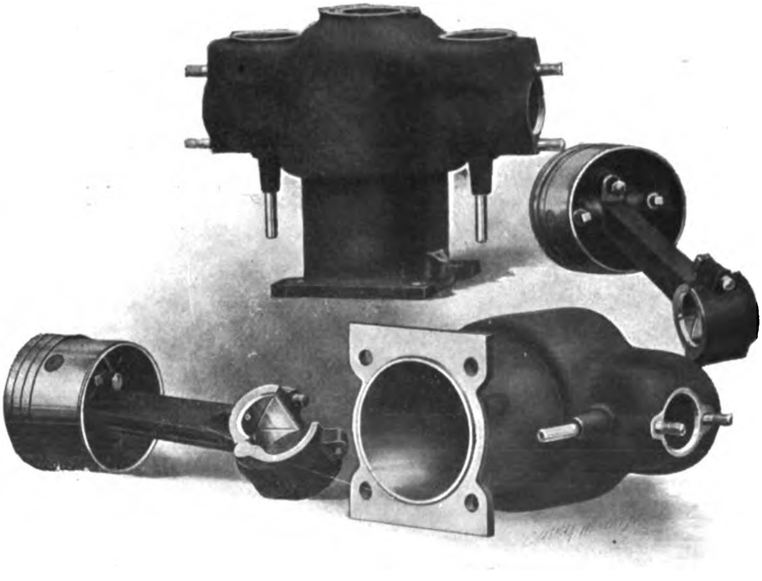


Fig. 36. Cylinders, Pistons, and Connecting Rods in Separately Cast Cylinder Type of Construction.
Maxwell-Briscoe Motor Company, Tarrytown, N. Y.

Fig. 36 shows the cylinders, pistons, and connecting rods of the Maxwell-Briscoe motor, Tarrytown, N. Y. This illustrates the separately cast cylinder type of construction.

Fig. 37 shows cylinders, pistons, connecting rods, crank-shaft, and fly-wheel of the Packard motor-car, Detroit, Mich. This illustrates the cast-in-pair type of cylinder construction.

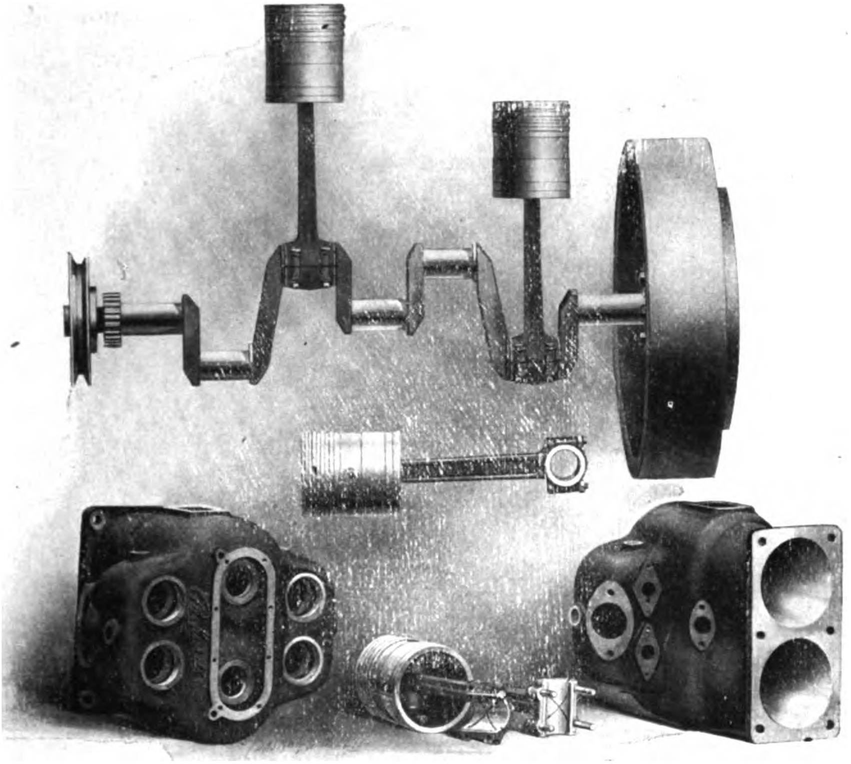


Fig. 37. Disassembled Motor of Packard Car, Showing Cylinders, Pistons, Connecting Rods, Crank-Shaft, and Fly-Wheel. Cast-in-Pair Type of Cylinder Construction. Packard Motor Car Company, Detroit, Mich.

In each of these illustrations the projecting spaces at the sides of the main cylinder are the valve chambers.

The *crank-shaft* in the best engines is machined from a solid forged slab of high-carbon steel or nickel-steel. By *high-carbon* steel, in the case of a crank-shaft, is meant a steel having a percentage of from .28 to .30 of carbon. Some of the nickel-steels now used in crank-shaft construction have a tensile strength as high as 225,000 pounds to the square inch, and an elastic limit of 135,000 pounds.

Fig. 38 shows the steps in the cold-machining of a crank-shaft as used in the Columbia car built by the Electric Vehicle Company,

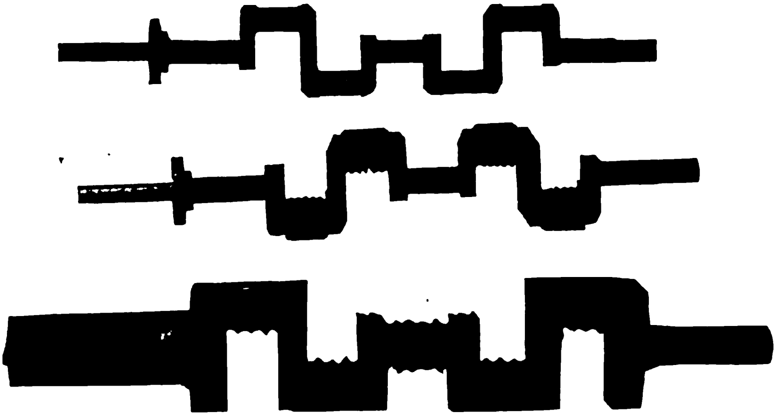


Fig. 38. Steps in Cold-Machining of Crank-Shaft from Solid Slab, for Columbia Car. Electric Vehicle Company, Hartford, Conn.

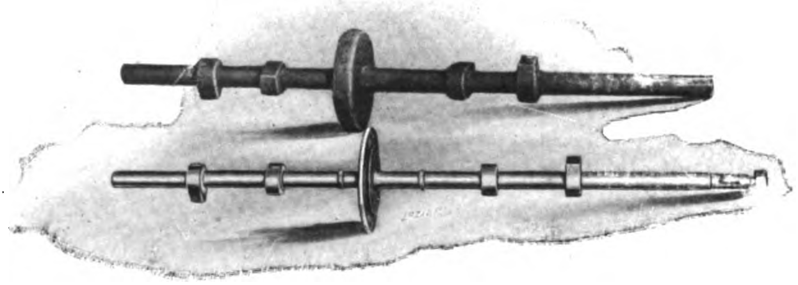


Fig. 39. Cam Shaft. Crucible Steel Forging and Finished Product. Lozier Motor Company, Plattsburg, N. Y.

Hartford, Conn. The next best construction is one in which the crank-shaft is hammered and bent into shape before machining; while the cheaper engines use a drop-forged shaft, which is not as likely to withstand severe strains as either of the two previously named types.

The modern tendency in high-grade engines is to observe almost equal care in the making of the *cams* and *cam-shafts* as is observed in the crank-shaft.

Fig. 39 shows a rough forging of crucible steel for the combined cams and cam-shaft as used by the Lozier Motor Company, Plattsburg, N. Y., together with the finished cam-shaft. The cam faces are hardened and ground to shape. Especial attention is also given to the bearings of the cam-shafts, some makers using annular ball bearings for this purpose.

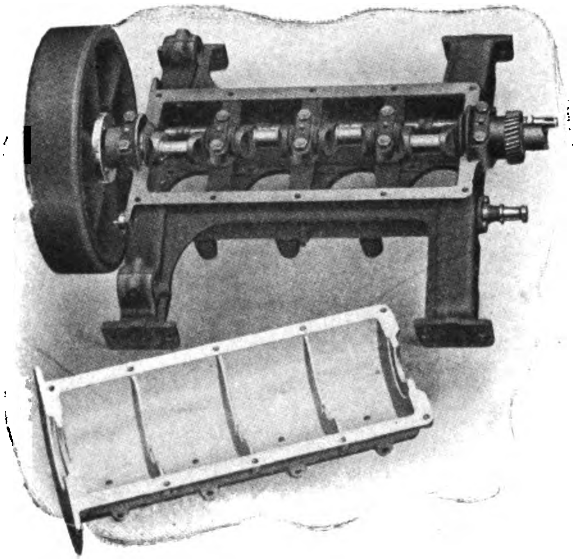


Fig. 40. Engine Base, Showing Support Piece Separate from Crank-Case, as Formerly Used by Premier Motor Manufacturing Company, Indianapolis, Ind. Case and Support are Now Made Integral.

The *crank-case* of most modern automobile engines is constructed of aluminum, partitioned into compartments in order to prevent an excess accumulation of oil at one end of the case in ascending or descending a steep grade. A great many engines use the crank-case as the motor support, relying on aluminum arms to carry the weight of the cylinders, crank-shaft, and fly-wheel. The low tensile strength of aluminum has been an objection to this type of construction, as the arms are liable to breakage. Hence some makers have adopted a light engine base made of stronger material, such as pressed steel, to which the aluminum crank-case proper is bolted. Fig. 40 shows an engine base and crank-case of this type of construction, as formerly used by the Premier Motor Manufacturing Company, Indianapolis, Ind.

The foregoing illustrations will serve to show typical examples of the main parts of the engine proper. The diagrams shown in Figs. 41 and 42 will serve to show more fully the relative location and operation of these parts—particularly the valve action.

Referring to Fig. 41, which is an end view of the Rambler engine made by Thos. B. Jeffery & Company, Kenosha, Wis., at the lower left-hand side will be noticed the cam-shaft and cam ready to push up on the valve-operating rod, which, when pushed up, actuates the rocker arm *D* to push down the valve proper, shown in the center at the top of the cut, against the action of the valve-spring *A*. While the valve is open, the charge is admitted in the case of the intake valve, or expelled in the case of the exhaust valve, during the period that the valve is kept open by the action of the cam. As soon as the cam has passed the lifter, the action of the valve-spring closes the valve with a sharp cut-off action.

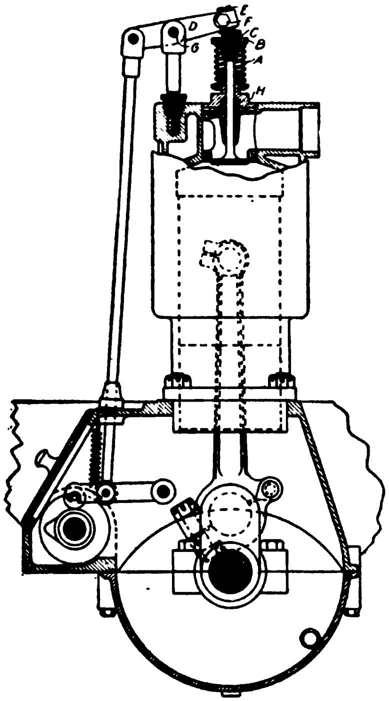


Fig. 41. End View of Rambler Engine. *A*—Valve-Spring; *B*—Spring Adjusting Nut; *C*—Lock Nut; *D*—Rocker Arm; *E*—Screw for Taking Up Play in Rocker Arm; *F*—Cap Screw for Locking *E*; *G*—Pivot Pin for Rocker Arm; *H*—Hexagon Nut for Screwing Valve Cage into Position.

Fig. 42 is a longitudinal view of the same engine, showing the inlet and exhaust valves *A* and *B*; also other details in connection with the ignition and cooling systems, whose positions it will be well to note now, but whose action will be described more fully under the later discussions devoted to ignition and cooling systems respectively.

The modern tendency with respect to valves, both inlet and exhaust, is to provide quick action and abundant opening space. With this in view, some makers have adopted two valves in place of one, or, in some instances, exceptionally large valves.

Fig. 43 shows three views of an exceptionally large valve as used in the 1908 Franklin engine. Theoretically, the ideal cylinder

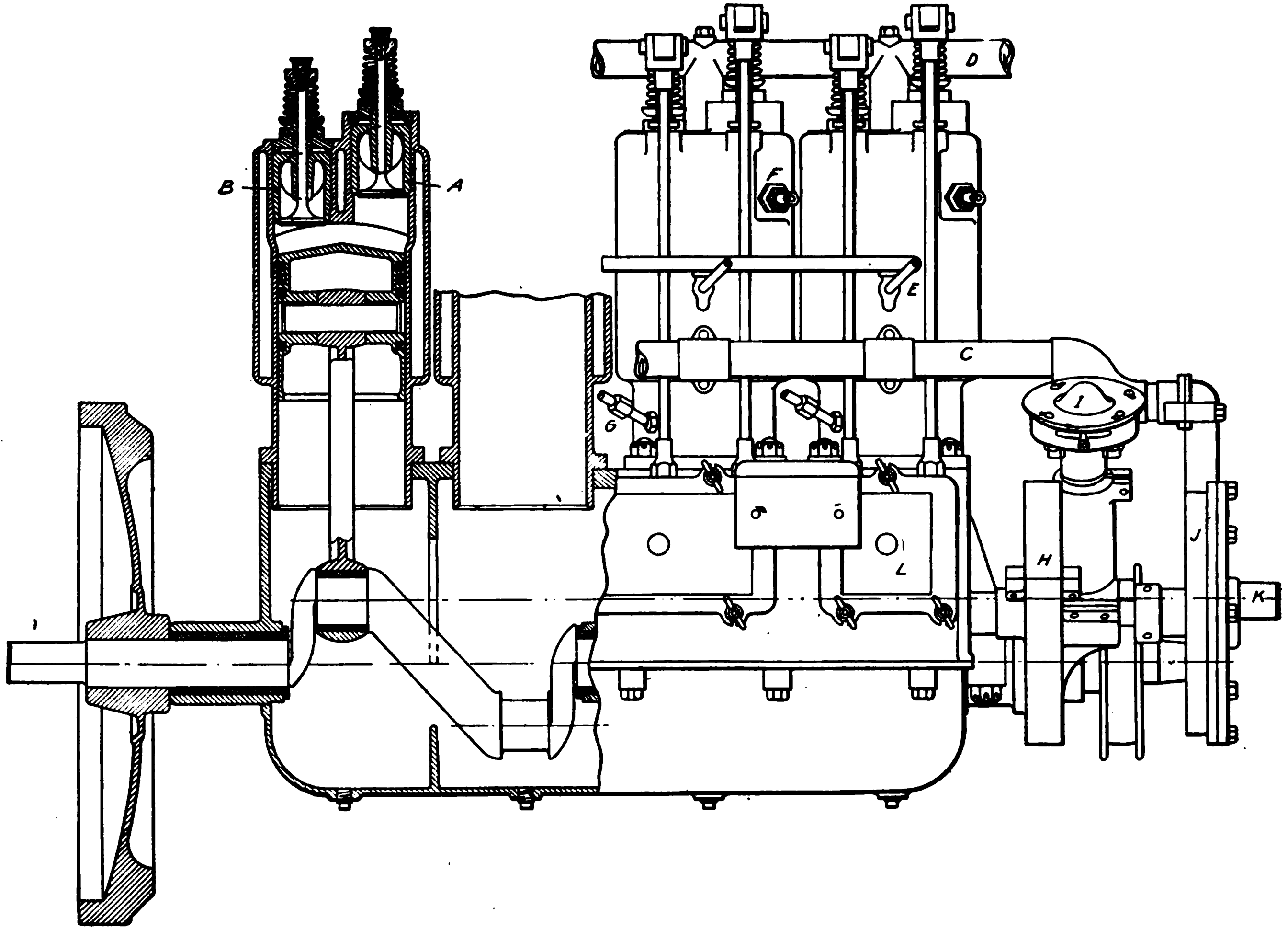


Fig. 42. Longitudinal Diagram of Rambler Engine.
A—Inlet Valve; *B*—Exhaust Valve; *C*—Cooling Water Inlet Pipe from Pump to Cylinder Jackets; *D*—Outlet Water Pipe from Cylinder Jackets to Radiator; *E*—Relief-Cocks; *F*—Spark-Plugs; *G*—Oil Pipes; *H*—Cam Gear Case; *I*—Commutator; *J*—Pump; *K*—Pump Intake; *L*—Hand-Plates on Side of Crank-Case.

would be one whose entire top would come off to let in a full charge, and then close immediately, the charge being next compressed and exploded, driving the piston forward, whereupon the top would then at once come off completely again and let out the burnt gases. Fig. 43 shows a valve of about one-half the cylinder diameter in width, and directly at the top of the cylinder.

CARE AND OPERATION OF VALVES

Seating of Valves. If the exhaust valve does not seat properly, there will be a lack of compression and loss of power that way, and also a weakening effect on the mixture.

If the inlet valve does not seat properly, there will be loss of compression; also there will be danger when the ignition takes place, of shooting back into the carbureter and having back-firing there.

The remedy is to grind the valves in place on their seats, first with emery and oil, and then with tripoli and water.

The valves, it may be, do not seat properly, because of being sooty or gummy. In this case they may not require grinding at all, the remedy being to clean them with kerosene.

In grinding valves, see that waste is placed in the opening to the combustion chamber so as to prevent the emery coming into the cylinder. The operation of grinding is repeated until both surfaces are bright and smooth, with a good fit.

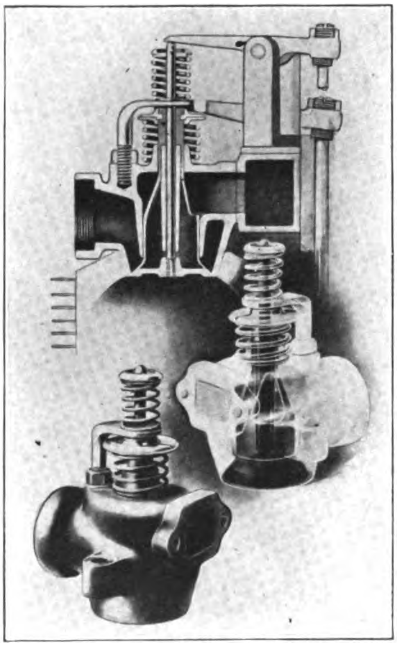
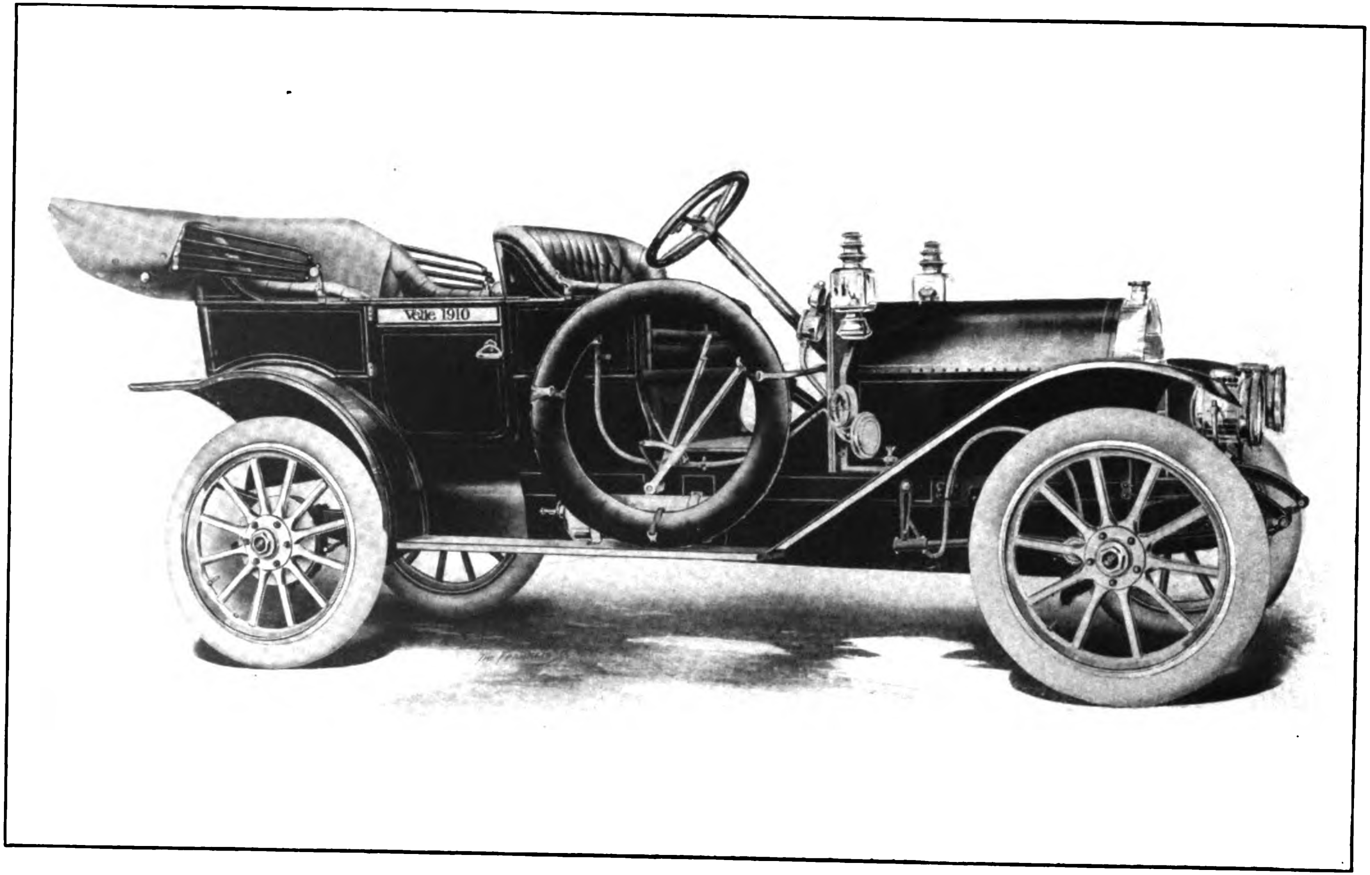


Fig. 43. Concentric Valve of 1908 Franklin Car.
H. H. Franklin Manufacturing Company, Syracuse, N. Y.

Care must be taken that no emery gets into the cylinder, as this will cause sticking or seizing of piston.

Almost all valves have a slot on the side opposite the stem.



VELIE "FORTY" TOURING CAR
The Velie Motor Vehicle Co., Moline Ill

This slot is put there so that a screw-driver bit may be inserted, and with a brace the valve may be rotated to and fro while grinding.

In grinding, just a small quantity of the abrasive paste should be used at a time, with plenty of oil. Make ten or twelve turns in one direction; then reverse. Wipe valve and seat clean occasionally, and note the extent of the bright line. At first this will be irregular and broken. But it must become a continuous band for good seating.

After this has been accomplished, wash valve and seat thoroughly with kerosene.

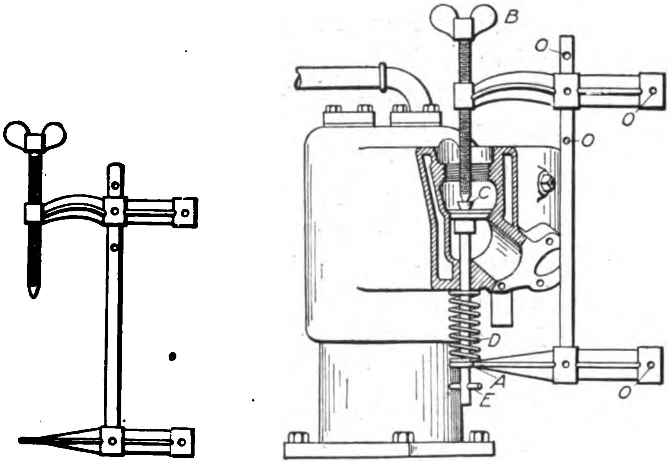


Fig. 44. Lifter Assembled. **Fig. 45.** Lifter Compressing Spring.

Tool for Removing Valve.

If valve is badly worn, it may be necessary to do some filing in order to avoid scoring and consequent catching.

Figs. 44 and 45 illustrate a convenient tool for removing valves. Its action is that of compressing the spring and lifting the washer so that the cotter or key can be removed. The directions for using this tool are as follows:

> Place fork *A* beneath washer or in coil of spring *D*. Turn thumb-screw *B* until point sets on top of valve *C*. Then screw down until spring *D* is compressed enough to remove key *E*.
>
> To remove, back up on screw *B*, remove lifter, and take out valve, so that necessary grinding, etc. can be done.
>
> To replace valve in position, simply reverse above instructions.
>
> *O* represents adjusting holes adapted for different lengths of cylinders and for getting over or under exhaust pipes.

Timing of Valves. If the exhaust valve closes too early, there will be some compression left when the intake valve opens, blowing back through the carbureter and affecting the mixture, and also likely to cause firing in the carbureter.

If the exhaust valve should close too late, it would be open when the inlet valve is open, weakening the mixture in the cylinder.

If the exhaust valve opens too late, there will be back-pressure caused by the cylinder being full of the exhaust gas. The cam is so set that the exhaust valve opens just before the beginning of the exhaust stroke, so as to avoid this back-pressure.

Improper valve timing may be caused by looseness of the reduction gear driving the cam-shaft.

* **To Set Valve for Proper Timing.** In a four-cylinder engine the four cranks are usually 180 degrees or half a revolution apart, so that there is an impulse or power stroke every half-revolution, occurring in the order of first, third, fourth, second.

The cam-shaft is driven by a gear fastened to the crank-shaft. The cam-shaft driving gear, mounted on the crank-shaft, has only half as many teeth as the cam-shaft driven gear which is mounted on the cam-shaft. Hence, for one revolution of the crank-shaft, the cam-shaft turns only through half a revolution. The cams are usually all keyed to the cam-shaft, or a part of the same, so that the adjustment of the cam-shaft with respect to the crank-shaft, if correct for one valve, is correct for all the valves.

The first thing to do in valve-setting is to establish the *dead center lines* on the fly-wheel. This is very easily done on a four-cylinder engine or two-cylinder engine, since the points on the fly-wheel will be diametrically opposite. In the diagram, Fig. 46, the dead center lines are shown by the vertical and horizontal lines respectively. By establishing these points and chalking the fly-wheel and the cylinder flange, and then marking the points on the fly-wheel and the cylinder flange with a scriber, the scriber mark on the fly-wheel and cylinder flange will coincide when the pistons of the first and fourth or second and third cylinders, as the case may be, are at the highest point of their travel, or on their head-end dead centers, respectively.

---

*The diagram used for Fig. 46 applies to the Franklin car. Instructions given by other manufacturers may vary from the practice of the H. H. Franklin Manufacturing Company.

The diagram shows the angles past the dead center lines at which the suction and exhaust valves usually open and close. It is well to determine these angles and mark them permanently on the fly-wheel when the engine is new and in first-class running condition. The diagram shows that the suction opens about five degrees past the dead center line, and closes thirty degrees past the opposite dead center. The first two strokes represented by one complete revolution in the direction of the arrow, represent the suction and compression strokes. The next half-revolution represents the explosion and expansion stroke. The fourth half-circumference represents the exhaust stroke, and the exhaust valve opens at a point fourteen degrees past the dead center line, closing at the end of the fourth stroke on dead center.

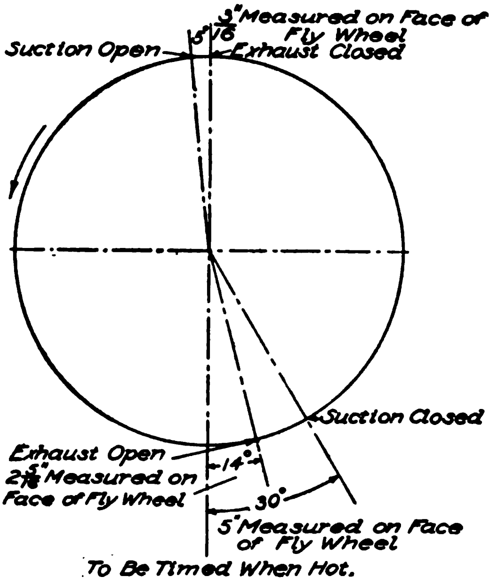

3/16" Measured on Face of Fly Wheel
5°
Suction Open
Exhaust Closed
Suction Closed
Exhaust Open
2 5/16" Measured on Face of Fly Wheel
14°
30°
5" Measured on Face of Fly Wheel
To Be Timed When Hot.

Fig. 46. Diagram Showing How to Use Fly-Wheel to Regulate the Setting of Valves for Proper Timing.

The angles indicated vary with different engines, distances along circumference as indicated in inches apply to a fly-wheel 19 inches in diameter.

To determine the instant at which valves are moved, insert a finger into the cylinder, and feel whether the valve is on its seat and does not turn freely. In some engines this can be done by inserting the finger through the spark-plug hole, as shown in the sectional view of the two-cylinder engine, Fig. 47. In other engines it may be necessary to remove the exhaust pipe in order to determine a movement of the valves. If the events are all relatively out of time, estimate how many teeth the cam-shaft gear will have to be turned in relation to the driving gear to bring the events correct. Having done this, chalk and number the gear teeth, and, removing the crank-shaft gear and keeping the crank-shaft stationary, rotate the cam-shaft gear one tooth or more in the proper direction. Then replace the driving gear, and retest. This is the course to pursue if a valve is opening too early and closing too early, or opening too late and closing too late, which is a sure indication that the cam-shaft does not bear the proper relation to the crank-shaft. If events of opening and closing of valves are not regularly out of time, the remedy does not lie in the adjustment of the cam-shaft, but in the adjustment of the individual valve push-rods. Provision for lengthening or shortening these is made in different ways in different engines; and this lengthening and shortening must be done for such individual valves as lift or close out of time, until all the events occur in uniform sequence—that is, until the angles past the dead center lines are the same for each valve.

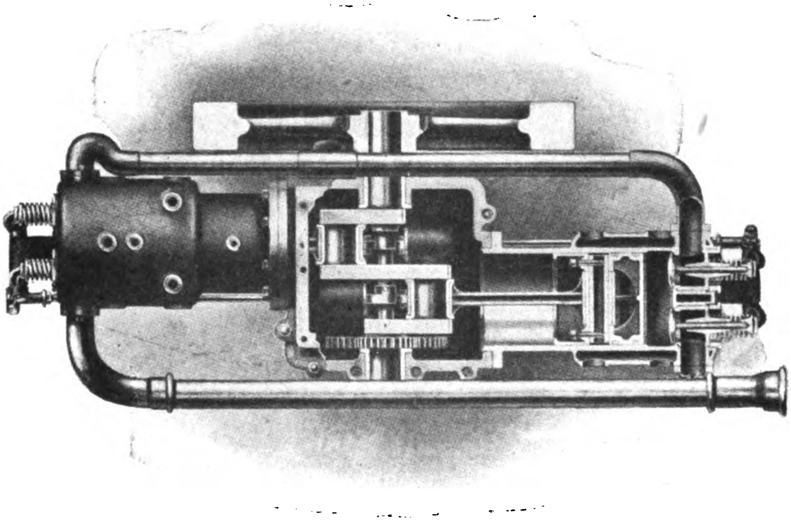


Fig. 47. Section of Two-Cylinder Engine Permitting of Access to Valves through Spark-Plug Hole.

Poor Compression. To improve compression, see that valves are not leaky; that is, regrind them, if necessary, until they seat perfectly and there is no leak. See also that there is sufficient oil, but do not supply a surplus of oil. Use just as much oil as can be used without causing smoke or carbonizing. Too much oil will cause the exhaust valves to become choked up.

A small pressure-gauge is applied to the spark-plug hole in the cylinder, in order to test for compression. Note the gauge reading when cranking slowly. In testing for leaks, soap-water is injected at all points suspected, and the location of the bubbles will indicate the points of leak.

Another cause of lack of compression may be the sticking of piston-rings, due to corrosion or carbonizing. Cleaning with kerosene is the remedy.

The compression may also be weakened by a leak at the base of the spark-plug.

Overheating is likely to be accompanied by bad compression.

The easiest way to test for poor compression is by cranking. If there is but little resistance, the compression is weak.

Corrosion. To remove corrosion in cylinders, put kerosene into them, and let it remain over night. At the end of each week, it is well to put in each cylinder a half-pint of kerosene; and in the morning, by opening the compression relief-cocks, the kerosene can be blown out of the cylinders. If cylinders are hardened with corrosion, it must be scraped out.

For removing corrosion, Mr. C. T. Ziegler, who conducts one of the most prominent selling agencies in Chicago, recommends a mixture consisting of two-thirds paraffine oil and one-third kerosene. He states that he has found this more effective than anything else in removing hard substance.

To have as little corrosion as possible, it is advisable to use only the highest grade of mineral oil.

COOLING SYSTEMS

The Air-Cooled Engine. As the efficiency and consequently the power of a gas engine depend on the temperature difference at the end of the stroke below that at the beginning, it will be seen that the more perfect the cooling system, other things being equal, the more efficient will be the engine, and the greater power per cylinder will it develop.

It is noteworthy that but a few years ago air-cooled engines were not considered a possibility for high power, as the limit to be reached in a 4 by 4-inch cylinder was about 5 horse-power. Larger cylinders were found to get too hot and to subject the metal to too great strains, besides burning up the lubricant. As compared with this rating of a few years ago of 5 horse-power per cylinder for the air-cooled engine, which rating may still be found in many textbooks on gas engines and automobiles, it is interesting to note how improvements in air-cooling have enabled the manufacturers of the Franklin car to build a 3¼ by 3¼-inch engine with a capacity of 12 horse-power to the cylinder.

The air-cooled type of engine is being used on a good many popular and successful cars; and the growing percentage of all American cars using air-cooled motors is certain evidence of the improvement of this type of engine.

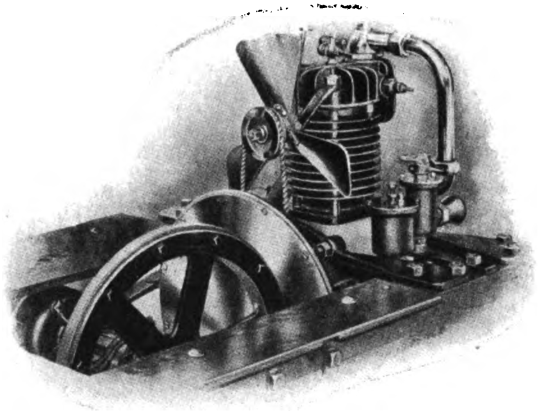


Fig. 48. Single-Cylinder Air-Cooled Engine as Used in Orient Buckboard.
Waltham Manufacturing Company, Waltham, Mass.

Fig. 48 shows a single-cylinder air-cooled engine as used in the Orient buckboard manufactured by the Waltham Manufacturing Company, Waltham, Mass.

Fig. 49 shows a two-cylinder opposed air-cooled motor with 4 by 4-inch cylinders, as used in the Holsman Automobile, Chicago. It lies lengthwise of the car. Special features of this engine are a double set of spark-plugs wired up so that a snap switch turns off one set and turns on the other; also cylinder-heads screwing into the cylinders instead of being fastened on by studs, thus facilitating quick removal and replacement of the cylinder-heads. The flat spokes of the fly-wheel act as a ventilating fan.

Fig. 50 shows the exhaust side of the Franklin six-cylinder engine. The illustration shows the regular exhaust pipe from the top and the auxiliary exhaust pipe from the bottom of the cylinders.

Fig. 51 shows the 1908 Franklin engine in "phantom" drawing, showing all the working mechanism. The large intake valve and

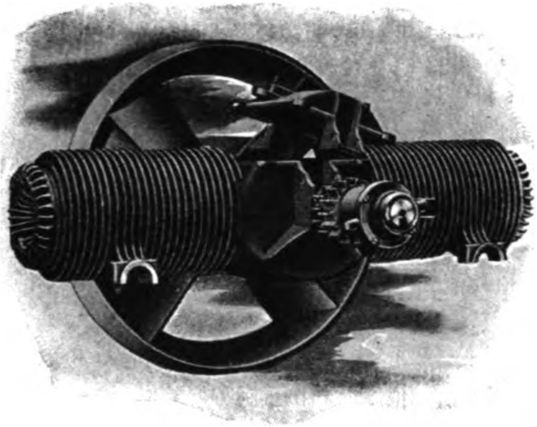


Fig. 49. Two-Cylinder Opposed Air-Cooled Engine as Used in Holsman Automobile. Holsman Automobile Company, Chicago, Ill.

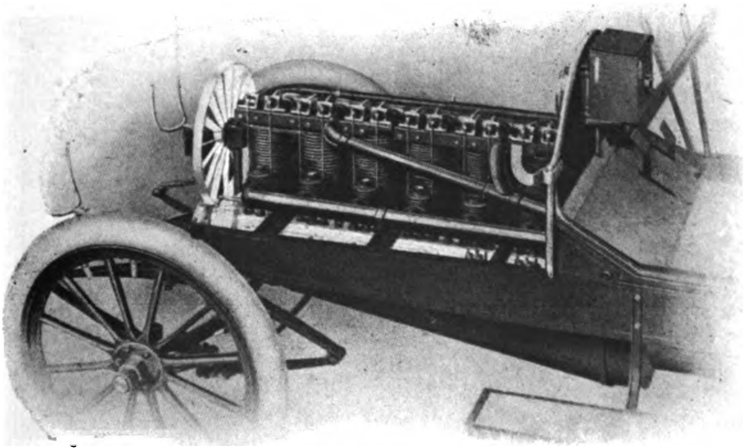


Fig. 50. Exhaust Side of Franklin Six-Cylinder Engine, Showing Regular Exhaust Pipe from Top and Auxiliary Exhaust from Bottom of Cylinders. H. H. Franklin Manufacturing Company, Syracuse, N. Y.

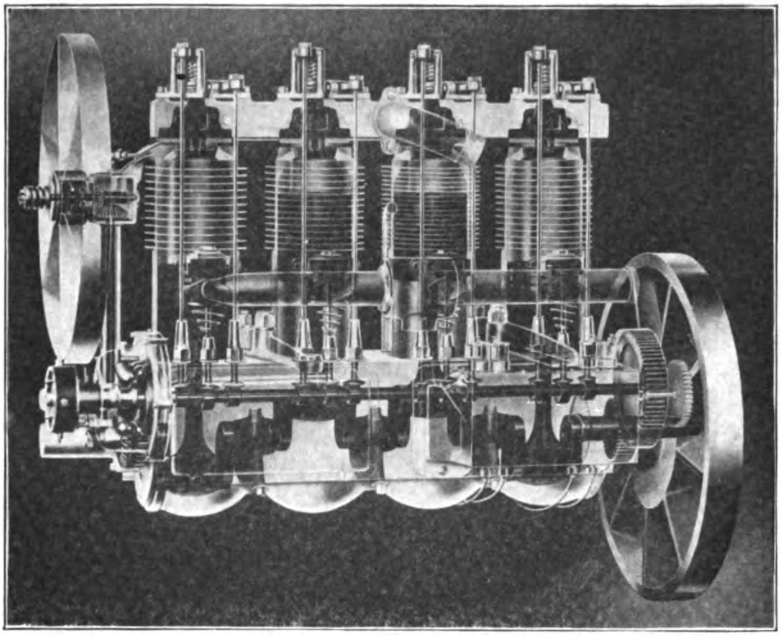


Fig. 51. "Phantom" Drawing of 1908 Franklin Air-Cooled Engine.
H. H. Franklin Manufacturing Company, Syracuse, N. Y.

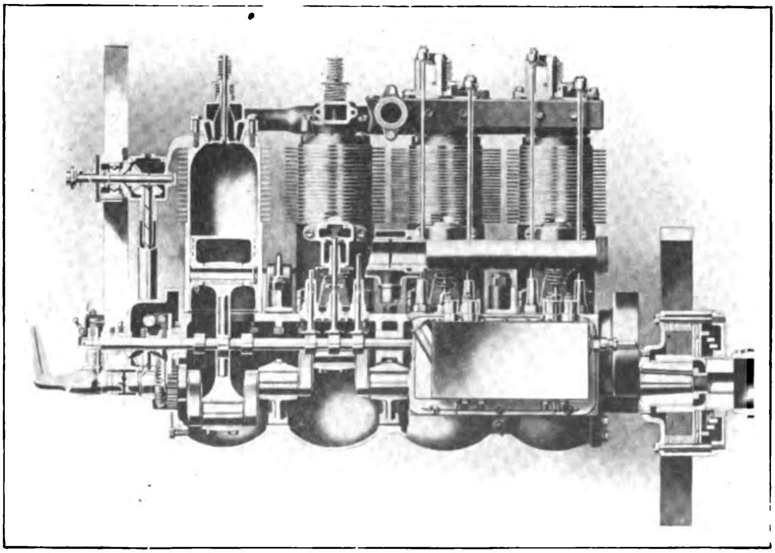


Fig. 52. Sectional View of Franklin 1908 Engine.
H. H. Franklin Manufacturing Company, Syracuse, N. Y.

auxiliary exhaust valves have already been mentioned. Another feature of this engine is the two fans—a gear-driven fan in front, and a fly-wheel suction fan in the rear. Fig. 52 gives a sectional view of the same engine.

In the Frayer-Miller motor, manufactured by the Oscar Lear Automobile Company, Columbus, Ohio, a centrifugal blower positively driven by the engine crank-shaft forces a directed current of air over and around the cylinder heads, walls, and valve-seats, in the direction required to produce most effective cooling. This results in an increased amount of draft as the engine speed is increased; also in a positive draft whether the car is in motion or standing still. Fig. 53 is an external view of this motor, showing the inlet side. The centrifugal blower, with its enclosed air-blast pipe, is seen at the right. Fig. 54 shows the same motor in section. The centrifugal blower is geared to the crank in a ratio of 4 to 1. The starting crank is attached to the blower shaft; and it is therefore easier to crank the motor in starting, on account of this 4-to-1 gear.

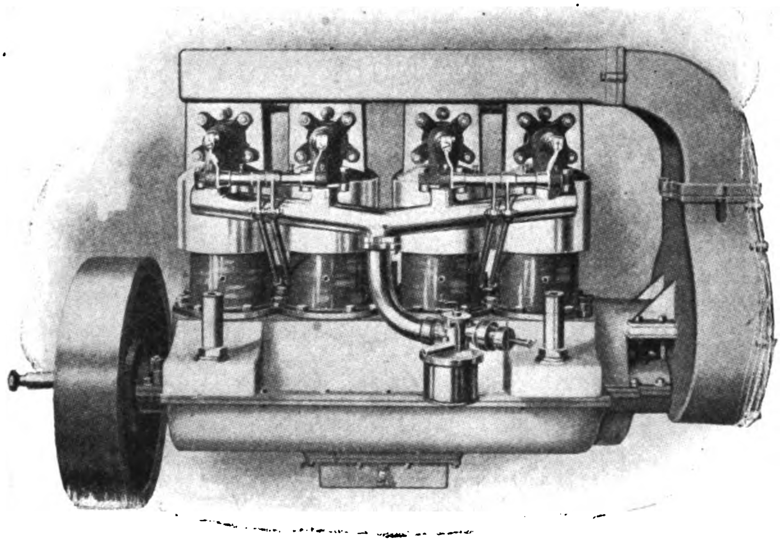


Fig. 53. External View of Frayer-Miller Engine Cooled by Centrifugal Blower, Inlet Side. Oscar Lear Automobile Company, Columbus, Ohio.

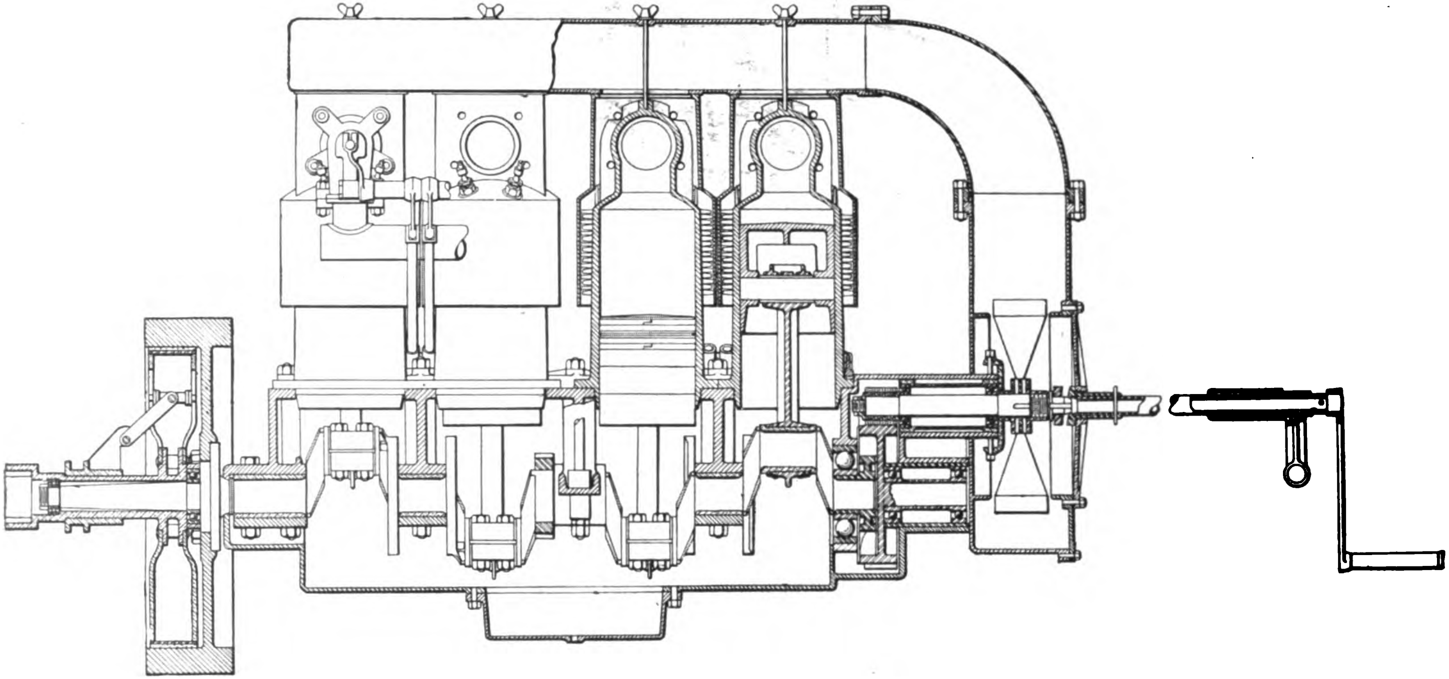


Fig. 54. Sectional View of Frayer-Miller Engine Cooled by Centrifugal Air-Blower. Oscar Lear Automobile Company, Columbus, Ohio.

A description of air-cooled motors would not be complete without mention of the *revolving-cylinder motor* as used in the Adams-Farwell car built by the Adams Company, Dubuque, Iowa.

Fig. 55 is an external view of this motor; Fig. 56 shows the motor in its mounting in the frame; and Fig. 57 is a diagram illustrating its operation. The cylinders revolve around a common center—the vertical stationary crankshaft. The pistons and connecting rods revolve around another common center—the single crankpin. The rotating cylinders throw off the hot air by the action of the centrifugal force, thus doing away with the necessity for a fan. The weight of the revolving cylinders serves the same purpose as a fly-wheel. By doing away with fan and fly-wheel, the total weight required is less than in engines of ordinary construction.

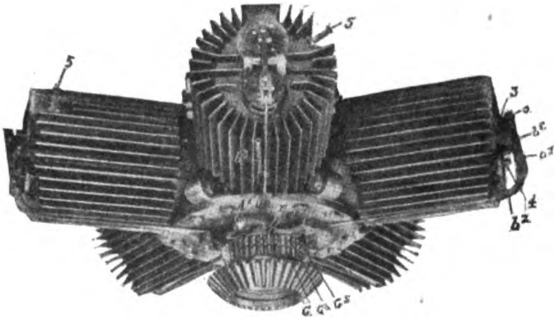


Fig. 55. Bottom View of 63-H. P. Revolving-Cylinder Motor of Adams-Farwell Car, with Cast-Iron Cylinders and Longitudinal Cooling Flanges.
Adams Company, Dubuque, Iowa.

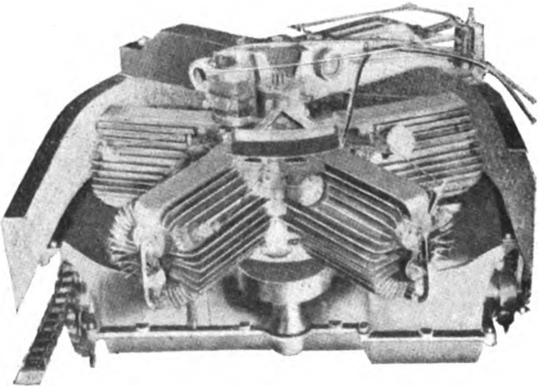


Fig. 56. Revolving-Cylinder Motor of Adams-Farwell Car, in Mounting on Frame.
Adams Company, Dubuque, Iowa.

Water-Cooling Systems. In water-cooled engines the cooling system consists of a water storage tank, connected by pipes to a circulating pump, from which pipes connect to the cylinder jackets, which open, at a point remote from the inlet pipe, to outflow pipes leading to the top of the radiator, back of which is a suction fan.

Fig. 58 shows a water-cooling system designed for a four-cylinder engine with independently cast cylinders. Fig. 59 shows a system for the twin-cylinder or "cast-in-pair" type of construction. Both of these diagrams show systems in which the radiator itself is the only storage tank. A good many cars have a storage tank for water, in addition to the radiator.

Referring to Fig. 58, it will be noticed that from the lower part of the radiator a tube runs to a water-strainer, which is an easily opened receptacle containing a small disc of wire gauze preventing the passage of sand and dirt into the water pump. The strainer is also provided with a cock for draining the entire water system. Most water systems provide also a cock in the pipe, just underneath the radiator. In draining the water system, be sure that both these cocks are opened; otherwise some water will remain in the system, which might result in freezing in cold weather.

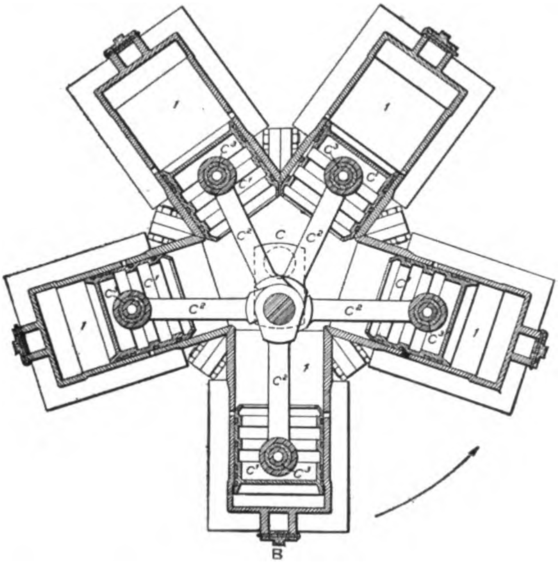


Fig. 57. Diagram Showing Operation of Adams-Farwell Rotating-Cylinder Engine.
Adams Company, Dubuque, Iowa.

Rubber hose connections in the water system are a source of great annoyance, and are being discontinued in the best cars, where they are being replaced by copper pipes with ground connections. Copper tubing, though longer-lived than rubber hose, has also disadvantages due to its liability to corrosion. Aluminum tubing has been used by some makers, though not to sufficient extent as yet to determine whether it can be recommended as the most desirable flexible tubing or not.

In order to insure the clearness of water in the water-circulating

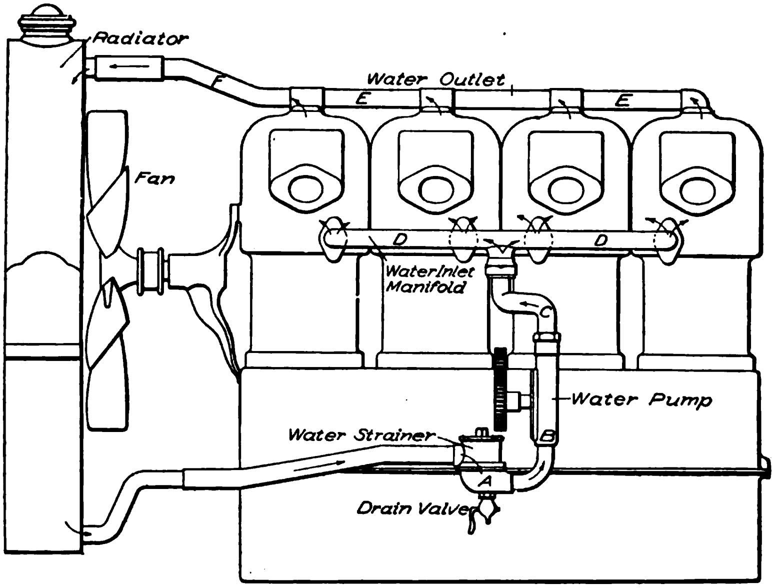


Fig. 58. Water-Cooling System for Separately Cast Cylinder Engine. E. R. Thomas Motor Company, Buffalo, N. Y.

system, a hose attached to city water should be allowed to pour into the water tank, the drain-cocks being left open and the engine kept running for some ten minutes, or until the outflowing water is perfectly clear and clean.

Radiators are either *tubular* or *cellular*, the latter class being

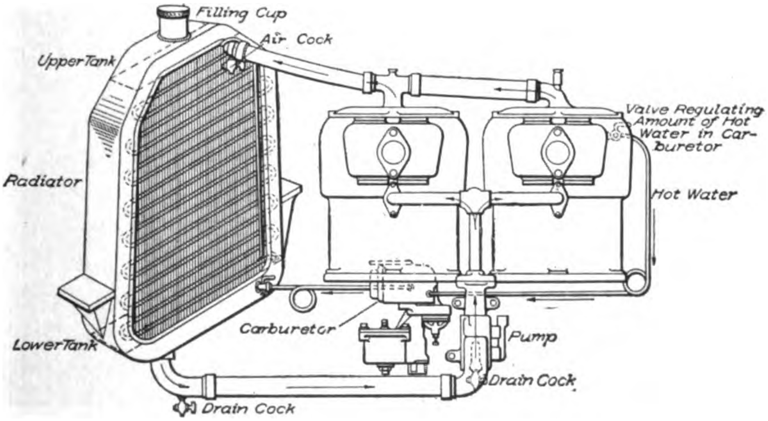


Fig. 59. Water-Cooling System for Twin-Cylinder Engine. Peerless Motor Car Company, Cleveland, Ohio.

also designated as the *honeycomb* type. The tubular type consists of either vertical or horizontal tubes, preferably of circular section and of rapidly radiating material (such as copper), with projecting fins or washers to assist in dissipating the heat. The tubular type has an advantage over the cellular type in that its construction is usually such that if a leak occurs in one tube the entire radiator is not put out of commission. In the cellular type, on the other hand, the main aim of the construction is to secure free play and flow of water in all directions through a continuous body of water, by means of lateral joints. This type of radiator is more efficient than the tubular, but more fragile. Fig. 60 shows the Reo tubular radiator; and Fig. 61, the Mayo cellular radiator.

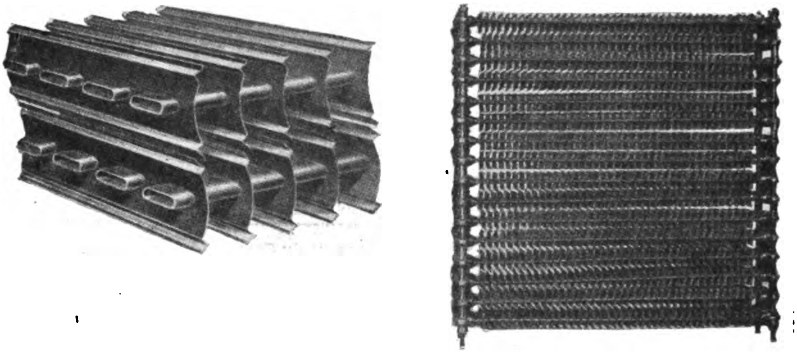


Fig. 60. Tubular Radiator, Showing Sectional and Separable-Construction Flat Tubing and Large Radiating Fins.
Reo Motor Car Company, Lansing, Mich.

Pumps are almost universally of the gear type, the water being lifted by the pressure of gear teeth against each other. A few cars use pumps with flat or square pistons, but the gear type is superseding these. In early cars, both pump and fan were belt-driven, but recent practice is in favor of gear drive from the cam-shaft.

The gear type of pump has an advantage over the piston type in that the strain is not periodic but is uniform throughout the entire revolution Fig. 62 shows the principle of operation of the gear type of pump.

Still another method of circulation is used in the Maxwell car, known as the *thermo-siphon* method, which is simply a siphonage in place of a pump. The circulation, depending entirely on temperature difference and not on engine speed, is greatest when the engine is hottest, which may be when its speed is low, as in going up a hill.

Fig. 63 shows the Peerless engine, giving a view of the encased geared pump at the right, also the belt-driven cooling fan. The arrows indicate the direction of water circulation.

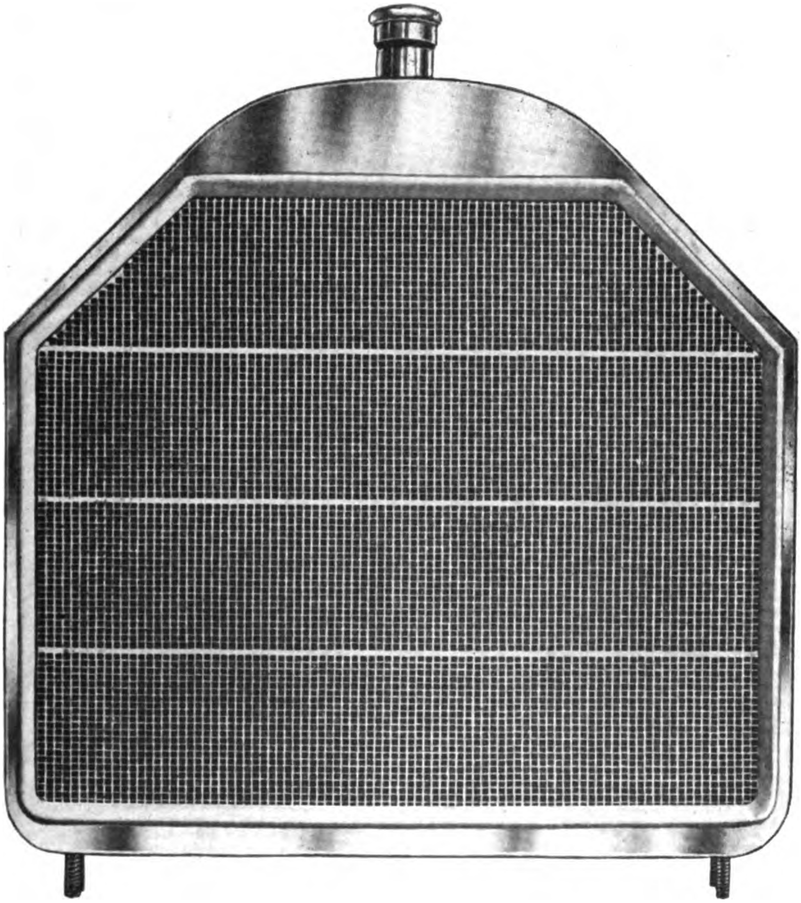


Fig. 61. Mayo Cellular Radiator of Type Used in Stearns 30-60-H. P. Cars. Mayo Radiator Company, New Haven, Conn.

Gaskets. In all flanged joints where a flange fits to another flange or to a cylinder or pump-shell or any other part in a water line or steam line, a compressible piece is inserted between the two

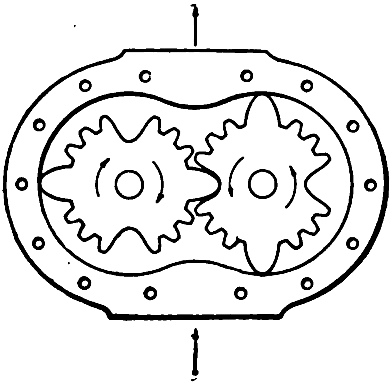


Fig. 62. Operation of Gear Type of Water-Circulating Pump.

metallic surfaces to make the joint tight against water or steam or whatever the circulating fluid may be. These compressible pieces are called *gaskets*. In steam-engine practice, gaskets are usually made of rubber or some composition of rubber, asbestos, and cotton. Owing to the high temperatures of gas engines, rubber composition gaskets are not so satisfactory as metallic gaskets.

Fig. 64 shows types of copper-asbestos gaskets made by McCord & Company, Chicago.

In emergencies, gaskets are easily made out of any stiff brown paper covered with graphite. The addition of graphite to a stiff brown paper makes the paper quite brittle; and in fitting it to the

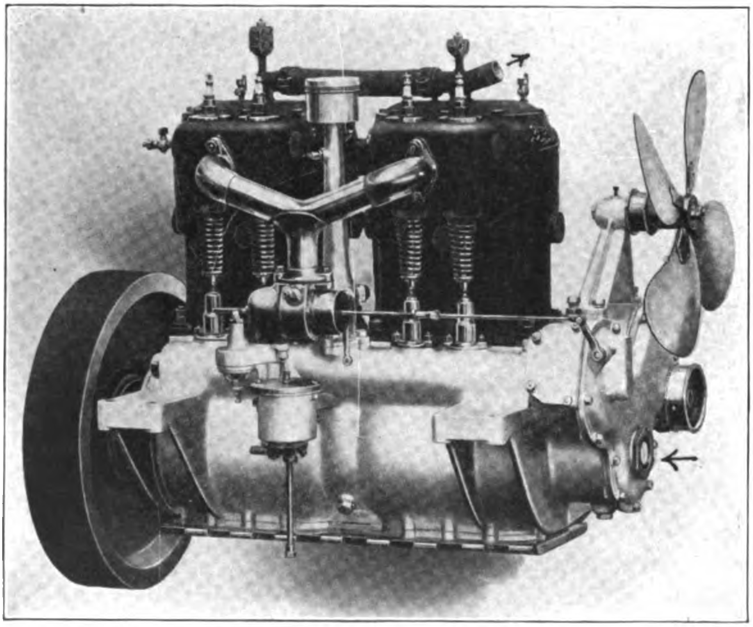


Fig. 63. Peerless Engine, Showing Cooling Pump and Fan. Peerless Motor Car Company, Cleveland, Ohio.

flange, it can be hammered into form, and the projecting part broken off with the hand.

If a gasket gives way in the cooling-jacket connection, it is apt to result in the jacket not receiving enough cooling water, owing to the leak. In such a case a temporary gasket of paper should be inserted. A leaky gasket can be detected while the car is running, by a hissing sound, if in the cylinder. If the leak is between the water-jacket and the cylinder, the engine will miss explosions if cooling water gets inside the cylinder.

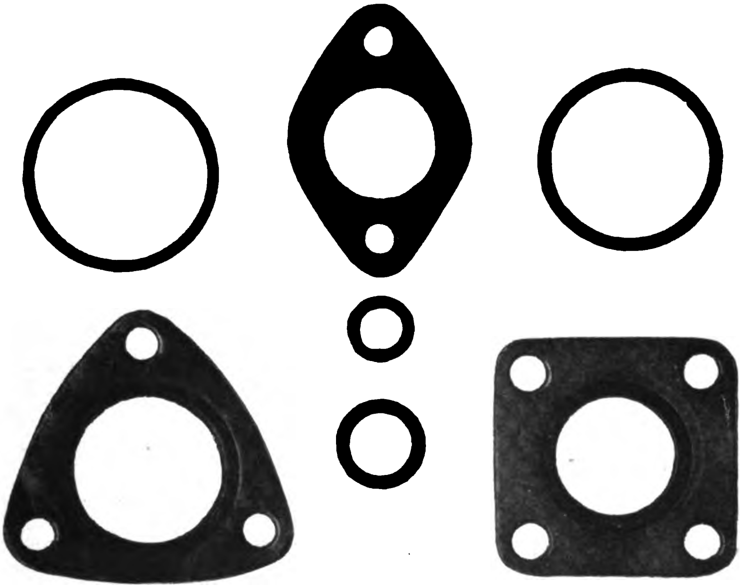


Fig. 64. Types of McKim Copper Asbestos-Lined Gaskets.
McCord & Company, Chicago, Ill.

Water in the cylinders can be detected by opening the pet-cocks and rotating the engine by the starting crank. Sometimes it is apparent from steam issuing from the muffler when the engine is running. If, after tightening all of the studs and nuts holding the engine-head to the cylinder, the leaking continues, a new gasket is necessary. To apply it successfully, the surfaces of the cylinder-head and cylinder should be thoroughly cleaned with gasoline, and any foreign material removed either by washing with gasoline or by scraping. The surfaces of both head and cylinder should next be coated with silicate of soda, and allowed to dry thoroughly. The gasket should then be soaked in the soda (if it is of asbestos or asbestos composition), and allowed to dry partially. If of paper and a temporary makeshift, it should be coated with graphite. Place the gasket on the cylinder, put the head in place, and tighten the studs and nuts. In doing this, be careful to distribute the pressure evenly—that is, tighten each stud and nut only a little at a time, until they have all been set home. After doing this, start the engine, and allow it to run one or two minutes without water in the tank. Stop it, tighten the studs and bolts again, and fill the tank with water. Do not use too long a wrench in tightening, and do not use too much force at once.

Overheating of Engine. When overheating occurs, everything begins to rattle and knock. You have premature ignition. It makes a "pinging" sound. The mixture ignites from the heat, instead of from the spark. If allowed to continue running when overheated, the engine will transmit its heat to oil in the cylinders, and if hotter than the burning point of the oil, the oil will burn and its odor will be noticed. Steam will be seen emanating from the cap of the radiator. The car will lose power and slow up. Overheating causes expansion of the piston, while at the same time all the parts become weaker and liable to distortion.

When overheating is noticed, the best thing to do is to shut down and let the parts cool off. In the case of an air-cooled engine, this is all that can be done; and after starting again, be sure that your mixture is not too rich or too plentiful. Before starting, disconnect the spark-plugs, and crank the engine a while so as to draw cool air through the cylinders. In the case of a water-cooled engine, some people would advise running the engine with spark well advanced, throttle closed, and engine free. This would cause rapid circulation of the water, which has previously been cooled by drawing off a part of it and putting in some cold water. This would be the course to pursue in case the overheating had been caused by working the engine too hard, and not because of lack of water. If water has all been used up, or if radiator and jackets are full of steam, avoid causing a sudden chill by pouring in cold water. Such a chill is likely to cause cracking of parts.

Other causes of overheating are found in defects in the water-circulating system, such as the failure of the pump to work, the presence of some obstruction in the water pipes, such as a piece of solder, or a leak in the water line. Overheating is also sometimes due to too rich mixture in the carbureter. A strainer should always be used in pouring in water, so as to prevent any dirt or grit getting into the pump or pipe-line.

A piece of rubber tubing is useful to carry as a temporary repair to leaks.

What is known as an *air-lock,* caused by air-bubbles in the pump, may impede water circulation. The remedy for this is to let the water flow out, and to keep pouring in new water.

Steaming Radiators. If the water in your radiator manifests a disposition to boil, and the gathering steam blows the filling cap off, do not try to cure the trouble by using an extra supply of solder on the cap. The pump or its driving connection may be broken; or a pipe or strainer may be clogged by waste or by a chance stone; or the carbureter may be feeding an excessively rich mixture; or there may be oil in the radiator, preventing contact of the water with the cooling metal surface.

Care of Water-Cooling System in Cold Weather. In freezing weather, it is very important that the engine be not stopped while the car is left out in the open; and that when the car is put away in its storage place for the night, all the water be drained out if exposed to freezing temperature, unless the circulating system is filled with a non-freezing mixture. There are various kinds of non-freezing mixtures on the market. Good mixtures can be made in the following ways:

1. A 50 per cent solution of wood alcohol.
2 Put 10 lbs. of chemically pure chloride of calcium and a handful of unslaked lime into a pail of water. After this preparation is carefully mixed and dissolved, pour into the radiator or tank through a strainer.
3. A 40 per cent solution of glycerin and water.

GASOLINE SYSTEM

The gasoline or fuel system consists of the *gasoline tank,* which is sometimes provided with a reserve or emergency chamber, and usually with a dirt or sediment chamber; *piping,* leading to mixer or carbureter; the *carbureter* itself, which will be described more fully in detail; and pipes leading from the carbureter to the valve-chambers of the engine, the piping being provided with necessary cocks and control valves.

Fig. 65 shows the gasoline system of the Thomas Flyer, made by the E. R. Thomas Motor Company, Buffalo, N. Y. The *gasoline tank* is placed under the forward seats, and contains twenty gallons. On the extreme left of the tank, a *Reserve Chamber* (*A*) is partitioned off. It is connected by a pipe *B* to the main chamber. The valve *C* in this pipe should be kept closed until it is necessary to admit the gasoline in the reserve chamber, which holds one gallon. The *sediment and water receptacle* (*D*) is shown at the bottom of the tank, which is drained by the valve *E*. There is also a shut-off valve in the line to the *carbureter* (*F*), which should be closed after the day's run, so as to cut off the

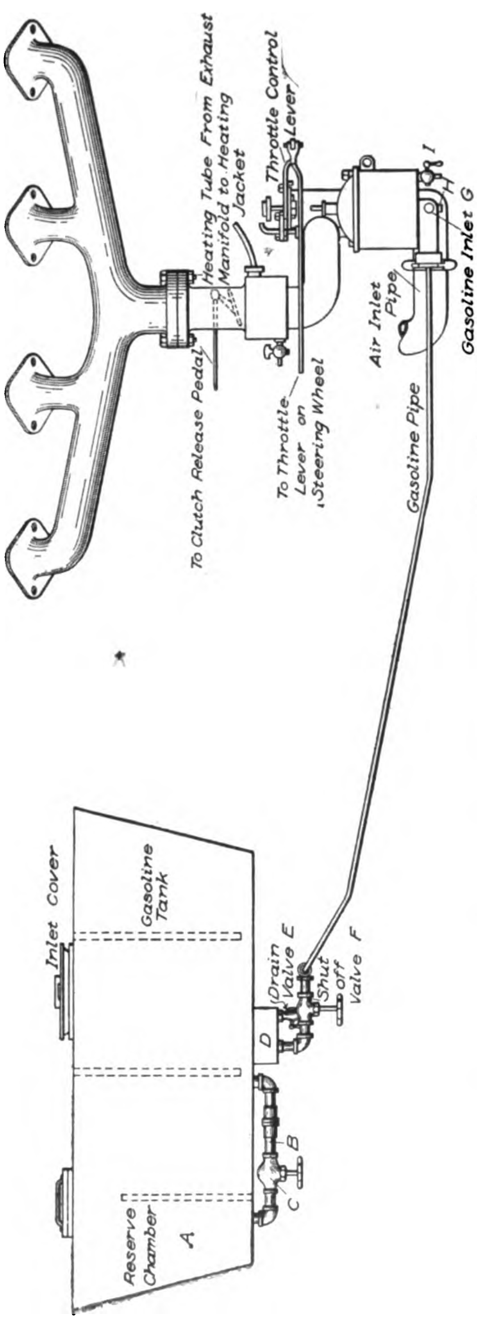


Fig. 65. Gasoline System of Thomas Flyer. E. R. Thomas Motor Company, Buffalo, N. Y.

gasoline supply from the carbureter, as the gasoline might overflow past the needle-valve, and, evaporating into the room, might cause a vapor which would prove dangerous on striking a match.

Fig. 66 shows the gasoline system of the Peerless motor-car, Cleveland, Ohio, giving a little more detail than is shown in the previous figure. In this system the filter and sediment catcher are in the pipe-line at its lowest point. Beyond this filter is an additional shut-off valve in the line to the carbureter. It will be seen that the mixing chamber of the carbureter is surrounded by a water-jacket connected to the regular water system. The water coming from the heated cylinders warms the mixture.

Gasoline Tank. Water or sediment in the gasoline is likely to cause a great deal of trouble in case it gets into the pipe-line or carbureter. Where the gasoline tank is not provided with a sediment drum, particular care needs to be taken not to substitute a cork or a wooden plug for the metal cap of the gasoline tank, or, in case a leak has been repaired, to see that all solder is cleaned out. The best remedy in case the gasoline tank has no drum, is to provide one. The gasoline intake leading to the carbureter leads from this drum, which is a small projecting cylinder at the bottom of the gasoline tank. The intake pipe should be screened, the gasoline rising upwards through the screen. There should be a cock or plug at the bottom of the drum, to permit of the withdrawal of any water or sediment that gathers there. Water, being heavier than gasoline, sinks to the bottom of the drum, and there is thus no danger of its getting into the carbureter. Another advantage is that gasoline will go into the drum up to the last drop.

As soon as the slightest leak manifests itself in the gasoline tank or line, it should be attended to In putting out a gasoline blaze, much more effective results are obtained by throwing sand or dirt on the fire, than from the use of water. It is advisable to have several buckets of sand or salt on hand in an automobile garage, to use in case of emergency. Leaky gasoline pipes have been the cause of a number of heavy losses, and careful inspection of the pipe-lines should be made regularly.

Gauge-glasses on gasoline tanks, while at first sight appearing convenient, constitute an additional breakable feature which can be dispensed with, with very little inconvenience.

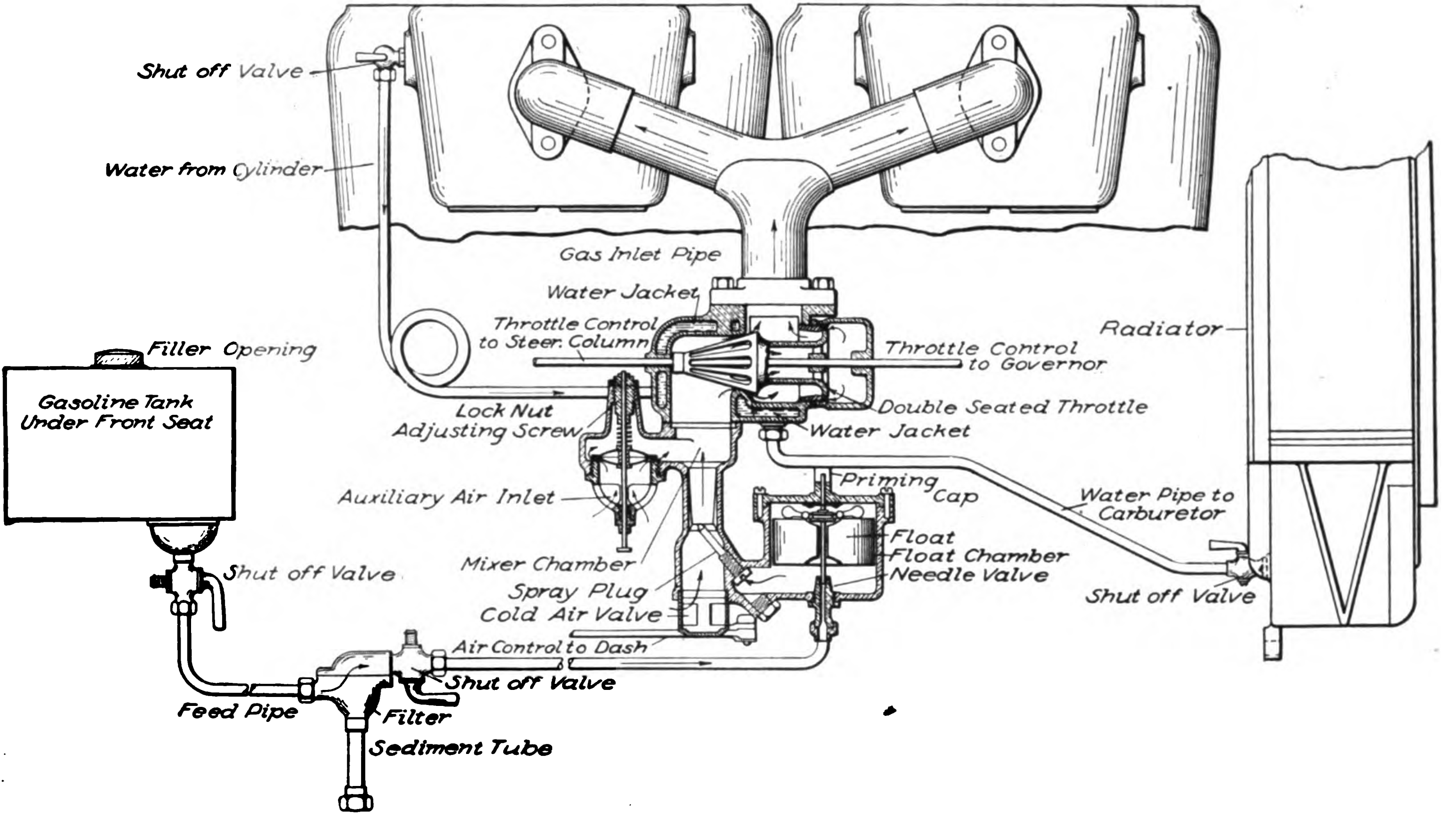


Fig. 66. Gasoline System of Peerless Car. Peerless Motor Car Company, Cleveland, Ohio.

Grades of Gasoline. What is known as *High-Test* gasoline is a variety of gasoline which possesses certain advantages in industrial processes. For general driving purposes it is not worth the advance in cost. It is easier of ignition than ordinary gasoline. There is not so much heat in it, nor so much mileage, as in ordinary gasoline. It does, however, explode more instantaneously, and hence gives power more quickly. It will not drive a car so long a distance as the same amount of ordinary gasoline.

Gasoline is graded according to its specific gravity expressed in terms of the scale on Baumé's hydrometer. Thus, gasoline graded at 65 or 85 degrees means that the hydrometer would sink to these figures on the scale. Baumé's hydrometer is the instrument generally used for testing specific gravity. To find the specific gravity, knowing the point on the scale to which the hydrometer sinks, we use the formula:

$$\text{Specific gravity} = \frac{140}{130 + \text{Hydrometer Reading}}.$$

It will thus be seen that the higher the reading on the hydrometer, the lighter will be the gasoline. Ordinary gasoline is about 68 degrees; high-test, so called, is about 76 degrees.

It is worth knowing that when the engine is warm it will run on kerosene, although it may not start with kerosene when cold. Kerosene is not good for the spark-plugs, on account of the sootiness resulting from its use. But in cases of emergency where gasoline cannot be purchased but kerosene can be found, the car can be run so long as enough gasoline is kept to start the engine and get it warm.

Carbureters. The relative proportion of gasoline and air to give the most effective explosive mixture, is subject to some variations dependent on the weather. No fixed rules can be given that will apply to all types of carbureters. Hence it is extremely desirable that the operator of a car be thoroughly familiar with the principles of operation and methods of adjustment of the carbureter on his car, so that he can adapt it to varying conditions so as to secure the most effective results. The injunction "Don't change the adjustment of the carbureter," which used to appear in instruction books, was very poor advice, and resulted in unnecessary troubles and needless calls on the repair shop on account of carbureter adjustments.

Having once adjusted the carbureter for making a proper mixture for a certain kind of weather, the action of the carbureter itself must be automatic in maintaining this mixture under all varying conditions of engine speed and load. This self-regulation to maintain the proper mixture, is attempted in different ways in different carbureters.

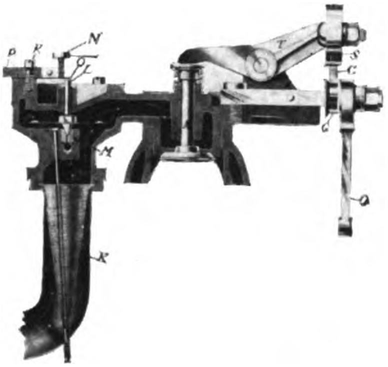


Fig. 67. Carbureter of Cadillac Single-Cylinder Car, Spring-Operated, without Float-Chamber.
Cadillac Motor Car Company, Detroit, Mich.

The Cadillac Motor Car Company, Detroit, Mich., regulates it by means of spring action in a carbureter that is very simple, without any float-chamber.

Fig. 67 shows a section of this carbureter. Its action is as follows:

The air is taken in at the end of the inlet pipe *K*. The intake of the air caused by the suction of the piston lifts the valve *L* and forms a partial vacuum at the terminal of the gasoline passage *M*, the screw *N* being adjusted so as to allow the valve *L* to lift from its seat just far enough to admit the proper amount of gasoline to form with the in-going air the proper mixture. The adjusting screw *N*, which regulates the amount of gasoline, should be adjusted only in case of improper mixture.

To secure the greatest efficiency, the mixer valve (which admits the gasoline into the carbureter) must open wider when the engine is running at high speed than is necessary when running at low speed.

The method of this adjustment is shown in Fig. 68. When the adjusting screw is located as shown in *A*, the spring *Q* cannot act; hence the adjustment needs to be changed. In Fig. 68, *B* shows the spring free to act to its full limit. With this adjustment it will be found that when the engine is running at low speed, the needle-valve moves so slowly that it has not sufficient momentum to cause the spring to yield. When, however, the speed increases, the volume of air comes against the diaphragm of the valve at a more rapid rate, and causes the needle *L* to strike against the spring *Q* with such force as to make it yield, thus allowing the mixer valve *L* to open wider at this high speed than it did at low speed. Under these conditions there is too much spring action, allowing the valve *L* to open too wide, and making the mixture too rich at high speed.

In this case the binder *P* must be adjusted so as to bring the adjusting screw *N* to the position shown in *C*, Fig. 68, giving less spring action than in *B*, and more than in *A*. By a little experimenting, the adjusting screw can be located in a position where it will allow sufficient spring action to give the desired mixture at both high and low speeds. The adjusting and experimenting should be done with the throttle wide open and with the spark-lever away back, so that firing does not take place ahead of dead center.

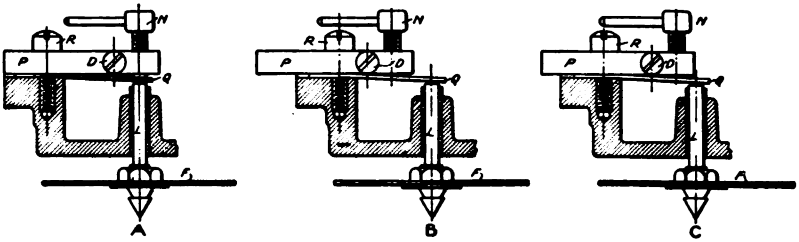


Fig. 68. Showing Adjustment of Spring Regulating Cadillac Carbureter. Cadillac Motor Car Company, Detroit, Mich,

The *float-feed* type of carbureter is very generally used; and a great many makes are on the market, with slight variations.

Fig. 69 is a section of this type of carbureter as used by the National Motor Vehicle Company, of Indianapolis. It is attached to the gasoline inlet line at the side of the engine, by an S-shaped brass pipe and flange. The *float-chamber B* of the carbureter contains a float *F*, which float actuates the gasoline inlet valve *H* by means of the float-lever *I* hinged at *J*. As the float-chamber fills with gasoline admitted through the inlet valve from the pipe-line leading to the gasoline tank, the float rises until it reaches a predetermined level, at which time it closes the inlet valve *H* through the action of the lever *I*. It will thus be seen that the connection to the gasoline tank is normally closed until the gasoline level falls sufficiently to cause the float to drop and operate the lever, thus permitting more gasoline to enter the chamber *B* until the normal level is again restored. The suction of the piston during the admission stroke of the engine creates a partial vacuum in the entire admission line, and this suction draws the gasoline through the spraying nozzle *D*. The amount of gasoline passing through the nozzle is regulated by the needle-valve lever *E*. The gasoline jet from the nozzle passes into the mixing chamber *C*. The quantity of air entering into the mixing chamber is controlled by the compressing air-valve *A* adjusted against the spiral spring *O* by means of the adjusting screw *M*.

It will thus be seen that the mixture can be regulated as to quantity both of gasoline and of air, each being independently regulated.

The quantity of mixture which goes to the engine is controlled by the throttle-valve *K*, which is simply a metal disc turned by means of the lever *P*, to which is attached the rod system leading to the operator at the front seat.

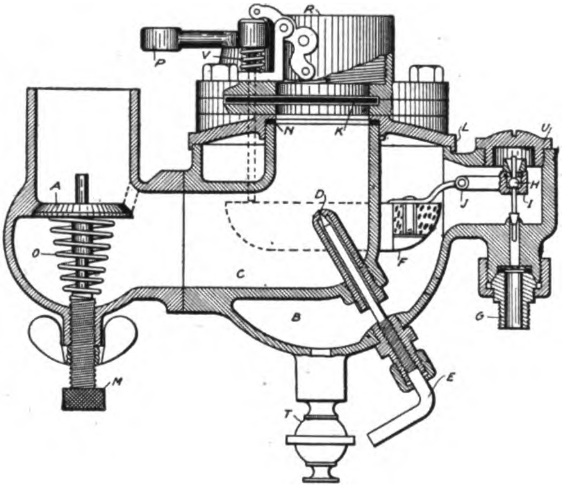


Fig. 69. Float-Feed Type of Carbureter, with Hand Regulation of Gasoline at *E* and of Air at *M*.
National Motor Vehicle Company, Indianapolis, Ind.

The proper mixture is obtained by adjusting the needle-valve *E*, which need be opened but slightly—usually only about three-fourths of a turn. If, when the cylinder relief-cocks are opened, black smoke and flame are observed, the mixture is too rich. After a bluish flame has been obtained, and the firing is regular, open the throttle-valve gradually. If the engine runs at low speed and fires regularly, but misses on high speed, tighten the tension on spring behind automatic air-valve, by screwing in the adjusting screw *M* until the engine fires regularly on all speeds and no black smoke is seen coming out of the exhaust.

Flooding of the carbureter will be indicated by the stopping of the engine when running, or by the gasoline running out of the carbureter when the engine is standing still, and is due to the float sticking and its not closing the inlet valve to the carbureter *H*. This can be remedied by taking off the carbureter after shutting off the gasoline by closing the cock below the tank. Remove the top of the carbureter, which shows the float to view. Its sticking is usually due to its binding on one side, it not being central. This can be remedied by loosening the screw in the center of the float, and moving the cork slightly to one side or the other.

Obstruction of the needle-valve of the carbureter will cause stopping of the engine or refusal to start. This is remedied by taking off the carbureter as above, and unscrewing the needle of the needle-valve, and then blowing through the valve. Such obstruction is generally caused by there being some particles of dirt in the gasoline.

Sometimes, if the car slows down from this cause, releasing the clutch and opening the throttle, allowing the engine to race for just a moment, it will draw this dirt out of the needle-valve. The disadvantage of this method is that the dirt is sucked into the engine cylinder, helping to score the cylinder by just that much.

In cold weather, water in the gasoline will freeze in the carbureter unless the carbureter is of the water-jacketed type employed in some cars. An almost imperceptible amount of water can cause this trouble, which can be detected by popping in the carbureter and perceptible cutting down of power of the engine, which acts as if the needle-valve of the carbureter were set for too little gasoline. When there is considerable water in the gasoline, it will stop the car entirely. This can be remedied by opening the cock at the bottom of the carbureter; and as the water is heavier than gasoline, it will drain out first. The cock directly under the gasoline tank should also be opened for a few seconds. If there is any suspicion about the gasoline in the tank having any water in it, it should be filtered through chamois skin.

Compensating Carbureters. The faster the engine speed, th greater will be the suction in the carbureter pipe, hence the greater the amount of gasoline drawn in. This will result in too rich a mixture for satisfactory operation. To provide for this, carbureters of the *compensating* type have a by-pass, as shown in Fig. 70. As the throttle-valve is opened wider, the by-pass valve gradually opens also, so that extra air is furnished the mixture, thus diluting it as the engine speeds up, and maintaining it at proper quality for all conditions of running.

Proper Mixture of Gasoline and Air. If the mixture is too weak in gasoline, the running will be affected. Explosions will be missed. If the mixture is too strong, the engine will fail to speed up. The action will be sluggish. It will not pull.

If the mixture is too rich, one can tell it from the presence of explosions in the muffler; from the very dense smoke, which is black; and from the sluggish action of the engine. Smoke caused by too much oil is blue, entirely different from the smoke caused by too much gasoline.

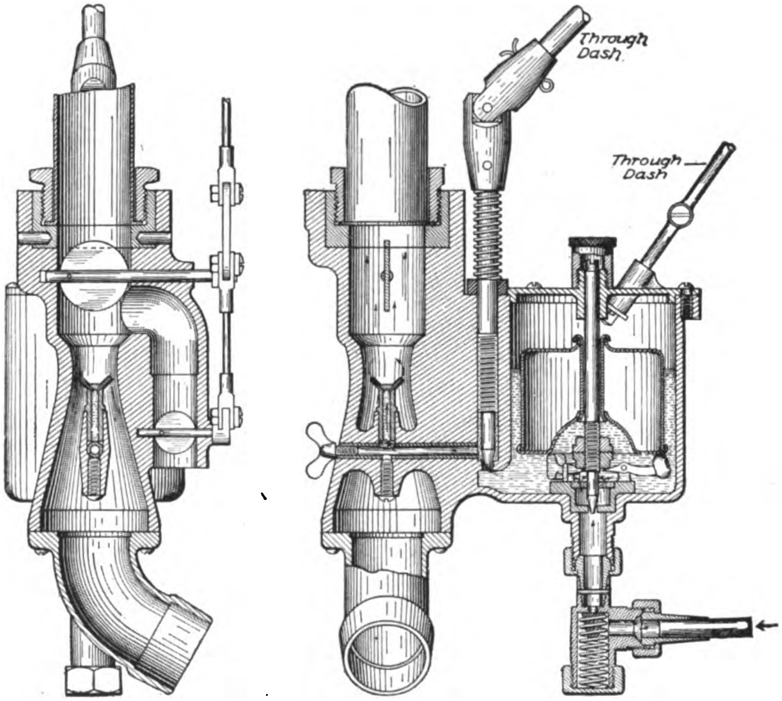


Fig. 70. Carbureter of Compensating Type, Admitting Increased Supply of Air as Speed of Engine Increases.
H. H. Franklin Manufacturing Company, Syracuse, N. Y.

In the case of a weak mixture, if it fires at all, it will make a pop in the carbureter, caused by the fact that a weak mixture will light readily in open air, but will not light well under compression. Popping back in the carbureter is caused by late spark or weak mixture. An engine with a very high compression will require a richer mixture than one having less compression.

Textbooks on gasoline engines usually make the statement that gasoline will ignite in a range of mixtures varying from one part by weight of gasoline to eight of air, up to as weak a mixture as one of gasoline to sixteen of air. However, there is no gauge about the automobile or carbureter by which one can gauge the relative weight. The only way to determine what is a proper mixture is by observing closely the action of the engine, supplying sufficient gasoline until indications of a rich mixture show themselves, as indicated above. Then slightly diminish the gasoline, until the condition of best running is secured.

DIRECTIONS FOR CONNECTING AND ADJUSTING A CARBURETER TO A MOTOR

1. Connect to the intake pipe on motor, as close to inlet valve as convenient, provided the motor does not overheat. The carbureter should not be placed where it will get hot, as this would change the quality of the mixture; but the closer you connect the carbureter to the inlet valve, the quicker the motor will respond to the throttle.

2. Great caution should be used to avoid traps or pockets of any description in pipe between carbureter and motor, or at low speed the fuel will condense and settle in such traps, and when the throttle is open for high speed the increased velocity of air through pipe will pick up this accumulation of fuel and cause smoke and trouble until pipe is clean.

3. Connect gasoline fuel to float-cup, with head enough to fill the cup. It is best to use brass pipe and fittings for gasoline, if convenient, as iron pipe is liable to rust and scale, which may clog inlet valve to carbureter and cause trouble.

4. Arrangements should be made to filter or strain all gasoline when filling tank, as it is very sure to contain some dirt or foreign substance collected from cans and barrels in handling.

5. When float-chamber is filled, screw needle-point down to seat; set the throttle very nearly closed for low speed; open needle about one-eighth of a turn; then try the motor with igniter in good working condition. When the motor starts, change the adjusting screw until you get a perfect mixture at low speed and no smoke (be sure you have it right at low speed); then lock adjusting screw in position with clamp.

6. Open the throttle by lever, and the motor will speed up under the proper mixture. Throttle may now be opened or closed at will, and no further adjustment will be required, except perhaps for a change of fuel.

7. Do not try to start your motor with the throttle wide open when you have an adjustment for low speed; but start it with throttle closed for low speed, which you can do very easily, as you can turn it at about the slow-running speed yourself, while, if you were to start with the throttle wide open, it might be necessary to flush the carbureter in order to get the fuel rich enough to start with at the speed you would be able to turn it over. This is why

nearly all float-feed carbureters have to be flushed for starting; they have no slow-speed adjustment.

8. On a motor controlled by throttle, the spring on the exhaust valve should be made stronger than is necessary with a motor drawing a full charge at all times; otherwise the partial vacuum created in the cylinder at low speed, owing to the light charge admitted, may unseat the exhaust valve and dilute the charge.

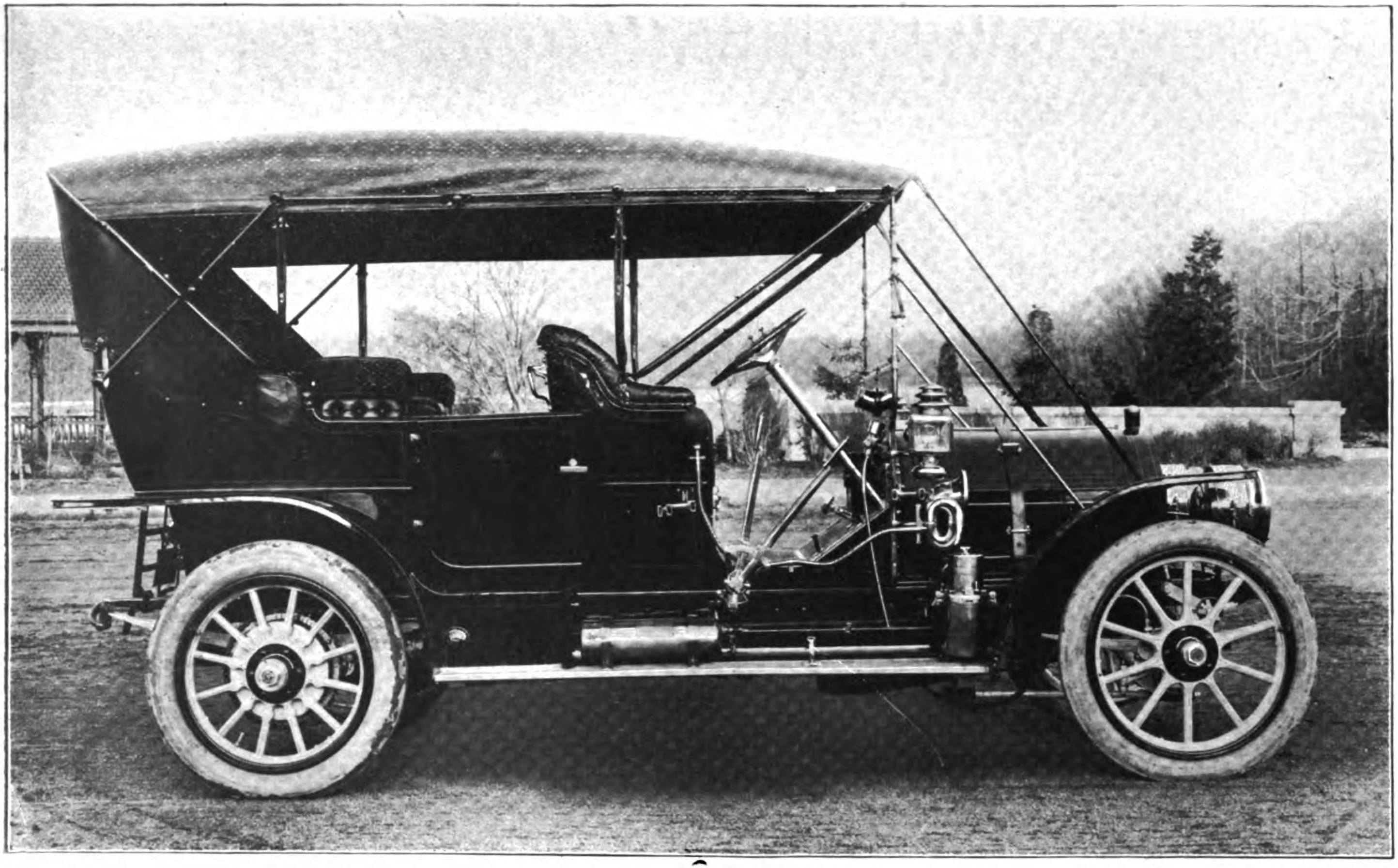
Sometimes water gets into the carbureter, and its contents must then be emptied. This is a point worth remembering in starting a car that has been standing in a heavy rain.

Sometimes the float will stick in the carbureter, and then needs to be cleaned.

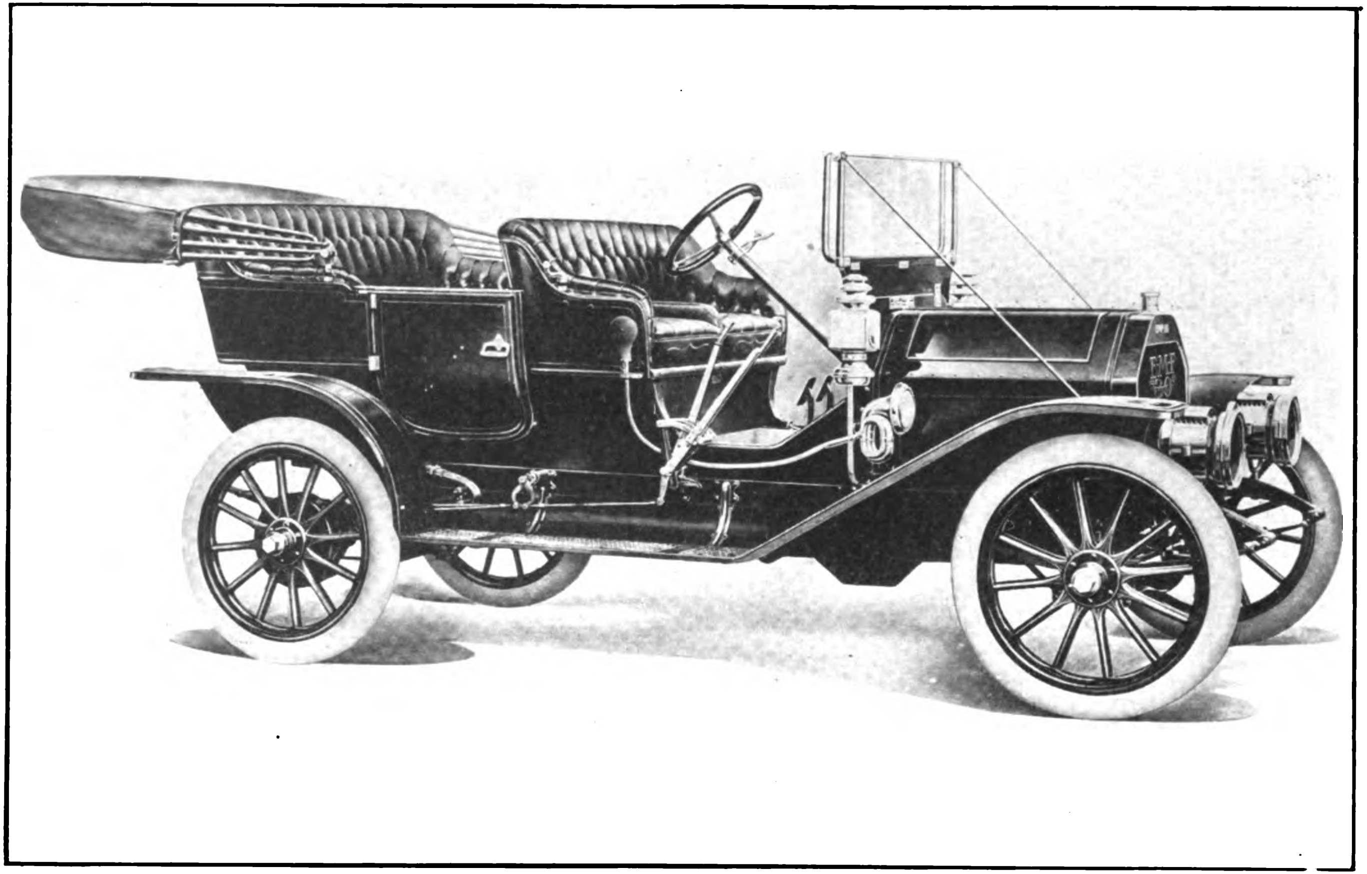
A carbureter should be used that has a drain-cock for taking out water.

It is very advantageous to have hot air for the air-intake. This is provided for by having the air-intake pipe end in a wide-flared mouthpiece close to the hot exhaust pipe of the engine.

Leaky Float-Valves. There is neither sense nor profit in neglecting to keep the float-valve of the carbureter tight. The effect of a leaky valve may not be very marked in cold weather as regards the quality of the mixture; but in warm weather, when the gasoline evaporates more readily, the leaking may make the mixture so rich as to make it impossible to start the motor unless the gasoline is turned off at the tank immediately on stopping. The best thing with which to grind-in the float-valve is pumice-stone. Emery is too hard, and it imbeds itself in the stem or seat of the valve, making trouble later on.



THOMAS FLYER.
E. R. Thomas Motor Company, Buffalo, N. Y.



THE E. M. F. "THIRTY" TOURING CAR
E. M. F. Co., Detroit, Mich.

AUTOMOBILES

PART II

IGNITION SYSTEMS

During the evolution of the automobile, no one part of it has caused more trouble than the ignition system. After much experimenting with various devices it has been determined that a single spark is not reliable enough to be depended upon when starting with a cold engine and a poor mixture. After starting, however, one definitely timed spark is better than the uncertainly timed stream of sparks produced by the usual vibrator coil. This is one of the points of superiority of the magneto ignition. An ignition system is now on the market which uses a dry battery as a source of current and produces a single accurately timed spark per explosion. This has given satisfactory results.

DRY-CELL AND JUMP-SPARK SYSTEM OF IGNITION

The simplest ignition system, and the one in general use on light runabouts, is the *Dry-Cell and Jump-Spark System.* A diagram of this system is shown in Fig. 71, which shows the ignition system of the Cadillac single-cylinder automobile.

In the center of the diagram are shown two sets or batteries of dry cells, *aaaa* and *bbbb.* Two sets of dry cells are used, simply so that if one set grows weak the other set may be put into service. Care must be taken in re-wiring to see that the current flows in the same direction in each battery, This can be determined by tracing the direction in which the current should flow. Taking for instance the diagram, when the switch *F* is closed in either direction, it completes an electrical circuit between one terminal of either battery and the metal frame of the car, as terminal *F* of the switch is electrically connected by a wire to the metal frame of the car. The commutator *P* has also one terminal electrically connected to the frame of the car. Following the current now, starting at *aaaa,* it flows through

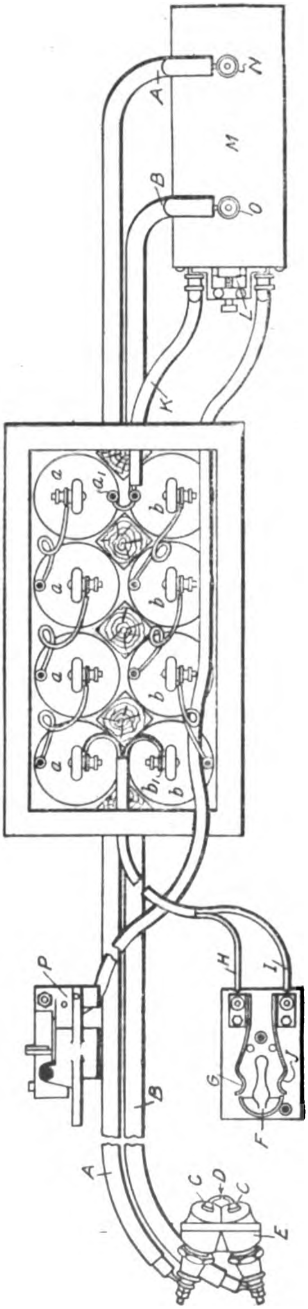


Fig. 71. Connections for Dry-Cell and Jump-Spark Ignition System for Single-Cylinder Engine. Cadillac Motor Car Company, Detroit, Mich.

H, and through the closed blade of the switch *F*; thence through the metal frame of the car to the commutator; and at such time as the metal contact of the commutator is closed, it passes from the commutator through the spark-coil or vibrator, entering at *L* and leaving at *K*. This completes what is known as the ***primary circuit.*** The reason it is called the primary circuit is that terminals *L* and *K* in the spark-coil are connected to the primary winding of the spark-coil. Wires *A* and *B* complete a circuit between the secondary winding of the spark-coil and the spark-plug *E*.

At *L* on the coil, there is a magnetic circuit maker and breaker, called the *trembler* or *vibrator*, which, when properly adjusted, makes and breaks the circuit through the primary winding of the coil, so long as the primary circuit is complete everywhere else. The action of the vibrator is continuous; that is, if the engine is not in motion and the battery circuit is closed, by closing the switch and bringing the metallic part of the commutator into contact with the circuit, there will be an uninterrupted humming of the coil. As soon as the engine is started, however, the make and break of the commutator, which is mechanically driven by the engine, causes intervals in the period of humming, which then takes place only during the ignition period.

The interrupted flow through the primary circuit, and through the primary coil of the spark-coil, causes an induced electrical current to pass through the secondary winding of the coil. This secondary winding is of much finer wire than the primary, and has a great many more turns. The result is that the induced electromotive force in the secondary coil is as many times higher than that of the primary as the ratio between the number of turns of wire on the coils. Every time there is a break in the primary circuit due to the action of the trembler in that circuit, an induced electromotive force of high pressure is set up in the secondary-coil system. This secondary electromotive force is so powerful that a small gap may be left in the secondary circuit and still the electric current will pulsate through the secondary winding, causing a spark to occur at the break. The wires of the secondary circuit must be thoroughly and heavily insulated, as they convey an electromotive force of several thousand volts pressure. The small gap above referred to is placed inside the cylinder, and is contained in the spark-plug.

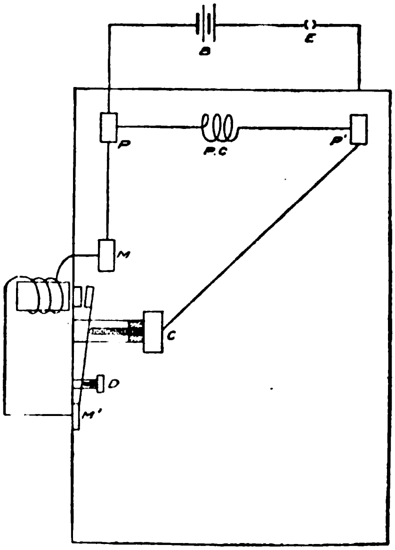


Fig. 72. Diagram Showing Action of Vibrator or Trembler.

Action of Vibrator. Fig. 72 is a diagram explaining the action of the vibrator or trembler—namely, the humming part of the spark-coil. *P* is one terminal of the primary circuit. From *P* a shunted circuit leads to the magnet terminal *M*, around the magnet, to the other magnet terminal *M'*; thence through the armature spring to the contact-screw *C*, which is connected to the other post *P'* of the primary-coil circuit. The regular primary circuit through the primary coil is indicated by *P C*.

As soon as the primary circuit is closed by the commutator *E*, the magnet in the circuit *MM'* becomes magnetized, drawing down the soft iron piece fastened to the spring, which has also served as a conductor between *D* and *C*. As soon as the spring is drawn down, the circuit through the magnet is broken; and the magnet being demagnetized, the mechanical return action of the spring draws it back again. As soon as it has sprung back far enough to touch the point of the contact-screw *C*, the original action is repeated. It will be noted, therefore, that the rapidity of action of the make-and-break mechanism depends on the adjustment of the spring and contact-screw.

Adjustment of Spark-Coil. The faulty adjustment of a spark-coil is apt to cause a great deal of trouble. Among the troubles which may be caused are: *Short life of batteries, burned contacts of the coil,* and *poor running of the engine.* The color of the spark at the length of $\frac{1}{16}$ inch should be a bluish purple. With an accurate adjustment, this characteristic color will be in evidence. In making adjustments, remove first the vibrator contact-screw *C*. Then adjust the vibrator spring so that the hammer or piece of iron on the end of this spring stands normally about $\frac{1}{16}$ inch from the end of the coil. Then insert the contact-screw *C*, and screw it in until it just touches the platinum contact on the vibrator spring. Be sure that it touches only very lightly. Screw down the spring-adjusting screw *D* until, when the circuit is closed, the vibrator rings with a high-pitch tone. Then start the engine. Then gradually release the spring-adjusting screw and contact-screw until that cylinder begins to miss fire. Then tighten up both screws just a trifle at a time, until the engine will run without missing explosions.

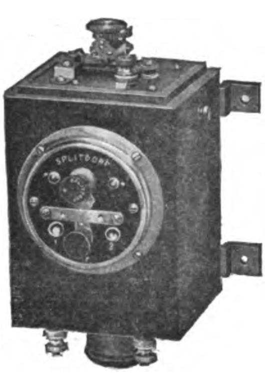


Fig. 73. Dash Coil for One-Cylinder Engine. Cover Removed.
The Splitdorf Laboratory, New York City.

It is common practice to adjust vibrators so that the spring gives a high, clear tone, and to draw the longest possible spark. This practice is extremely wasteful of battery force; and since it increases the tension of the current passing through the vibrators, the platinum contacts wear out rapidly, causing them to stick and the engine to miss fire. A happy medium can be learned by careful observation while adjusting the screws.

Figs. 73, 74, and 75 illustrate typical spark-coils. Fig. 73 shows a Splitdorf dash coil for a one-cylinder engine, the cover being removed; Fig. 74 shows a dash coil of the same make for a two-cylinder engine, one of the units being removed from case; and Fig. 75 shows a Splitdorf three-cylinder dash coil, also with cover removed.

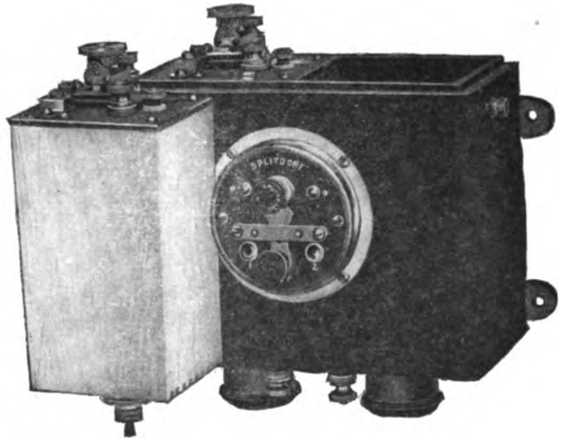


Fig. 74. Dash Coil for Two-Cylinder Engine. Cover Removed. Also note removable unit.
The Splitdorf Laboratory New York City.

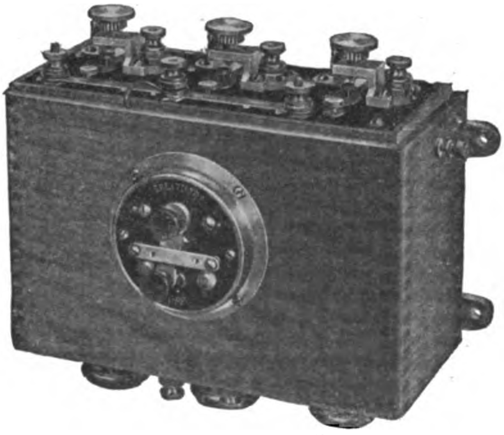


Fig. 75. Dash Coil for Three-Cylinder Engine.
The Splitdorf Laboratory, New York City.

Fig. 76 shows the principles involved in the wiring of a typical two-cylinder engine using dry-cell and spark-coil ignition. *A* and *B* are two batteries, each consisting of three cells. The three cells of each group are connected in series. *C* is the *spark timer* or *commutator*, which is controlled by the spark-lever so that the sparking may be made to occur earlier or later during the stroke of the piston. The shaft shown at *D* on the diagram is really the shaft *E*. Since the commutator is actually attached to the motor, it is shown separately in the diagram for clearness in showing the wiring connections. *F* is grounded to the motor frame, while *G* and *H* are both insulated from the motor frame. By the rotation of shaft *D*, which carries the commutator, the current is first permitted to flow between *F* and *G* when these two terminals are brought into contact by friction with the metallic periphery of the commutator. As the commutator continues to revolve, the fiber portion of the periphery advances between *F* and *G*, breaking the circuit between those two terminals. Meanwhile metallic circuit has been established between *F* and *H*. From these points current flows through the spark-coil, and sparks are caused alternately in the spark-plugs *K* and *L*. The switch key *N* shown in the center of the diagram is located on the dash. It will be seen by the connections, that either one or the other battery of dry cells may be connected at will. When the switch key is in the position shown, the battery *B* is in use; and when the switch key is over *P*, the battery *A* is in use.

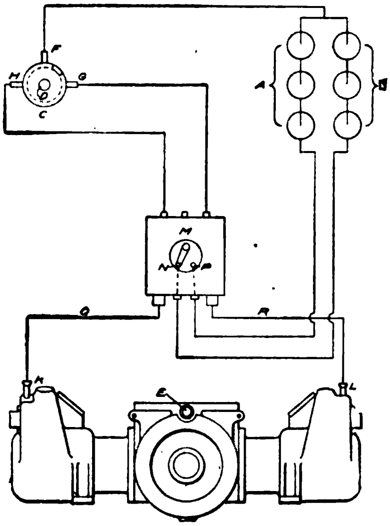


Fig. 76. Wiring Diagram for Two-Cylinder Engine Using Dry-Cell and Spark-Coil System for Ignition.

When it is desired to leave the car, or to use the engine compression as a brake, the switch key is either removed or placed in the middle or neutral position, and the electrical circuit is broken, so that no spark will occur, and hence the motor cannot be started until the key is replaced.

Wires *Q* and *R* connect the spark-plugs to the secondary or high-tension winding of the spark-coil, and are heavily insulated.

Fig. 77 is a wiring diagram for a four-cylinder engine, which is provided not only with dry cells but also with a storage battery. Otherwise the connections and operation are like the systems already explained for one-cylinder and two-cylinder engines respectively.

DIRECT-CURRENT SHUNT-WOUND DYNAMO SYSTEM

Dynamos for Charging Batteries for Ignition. For the purpose of utilizing the power of the gasoline engine to charge the storage batteries used for ignition, there are several makes of direct-current dynamos on the market. These dynamos are driven either by a belt from some moving shaft; or by a gear mounted on the commutator shaft of the gasoline engine, meshing with a gear on the armature shaft of the little dynamo; or by meshing of the gear on the dynamo shaft with teeth cut into the engine fly-wheel. The connection should never be made by the use of thin gear rings screwed onto the engine fly-wheel, as the centrifugal force when the engine races for even a few revolutions is apt to burst the gear rims at the thin part.

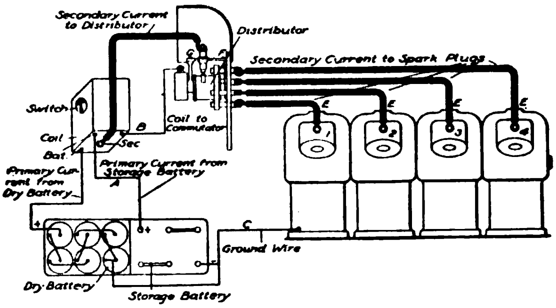

Secondary Current to Distributor
Distributor
Secondary Current to Spark Plugs
Switch
Coil
Bat.
B
Sec
Coil to Commutator
E
E
E
E
1
2
3
4
Primary Current from Dry Battery
Primary Current from Storage Battery
A
C
+
+
Ground Wire
Dry Battery
Storage Battery

Fig. 77. Wiring Diagram for Four-Cylinder Engine Using Spark-Coil in Connection with Dry Cells and Storage Battery for Ignition.

As the speed of any shaft driven by the gasoline engine will be variable, such dynamos require governors to regulate their armature speed so that it will be kept constant no matter what the speed of the driving shaft is.

All dynamos have a certain speed at which they generate their normal voltage and current. This speed cannot be exceeded without danger of burning up the insulation of the machine by its own excessive current, or damaging its running parts. Moreover, an increased voltage is very damaging to the entire ignition system, particularly the storage-battery cells; hence it is very important that a small voltmeter be connected in the circuit at all times when a charging dynamo is on the car, and that this voltmeter be kept in sight so that any faulty action of the speed governor of the little dynamo may be at once detected.

This system also requires a means of automatically disconnecting the dynamo from the battery as soon as the engine stops, so as to prevent the battery current running back through the dynamo. The current for ignition is taken from the storage battery at all times. Fig. 78 shows the connections for this system.

Fig. 79 shows a shunt-wound dynamo with its speed governor.

MAGNETO SYSTEMS

The most troublesome features of the shunt-wound constant-current dynamo are speed regulation and constant attention to proper voltage. Hence there has been a tendency to dispense with charging the storage battery while running—which is the real advantage of the shunt-wound dynamo—and to use instead a *magneto*. The magneto cannot be used for charging batteries, owing to the irregularity of its uncommutated or very roughly commutated electromotive force. The magneto may be either alternating-current or direct-current. In the latter case, there is no attempt as a rule at more than one commutation, for the reason that it is desired to have the *peak* of the electromotive wave curve occur regularly in unison with the engine speed, that is, the impulses generated by the magneto must be made to coincide with the times at which the sparking must take place. This is accomplished by gearing the magneto to the engine cam-shaft.

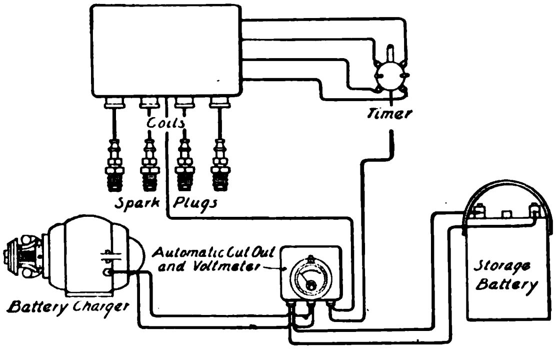


Fig. 78. Connections for Direct-Current Shunt-Wound Dynamo System of Ignition and Charging Storage Battery.

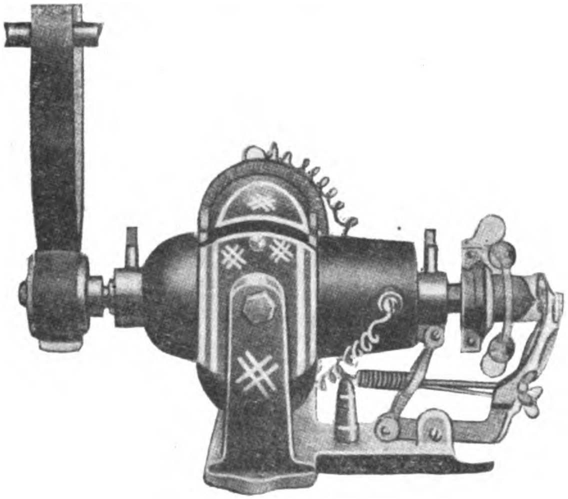


Fig. 79. Direct-Current Shunt-Wound Dynamo Driven by Gasoline Engine in Car and Used for Charging Storage Battery.

As above stated, the magneto cannot be used for charging storage batteries or for furnishing current for electric lights, both of which can be accomplished with the shunt-wound dynamo system. The only purpose for which the magneto can be used is for the ignition of the charge in the engine cylinders; and it is satisfactory for this purpose only when the engine is running at full speed. Hence an auxiliary battery and spark-coil system must be used for starting or at very slow speed of the engine. The magneto is a dynamo which can be built much more cheaply than a shunt-wound dynamo with speed governor, and can be built so small that it takes up much less room.

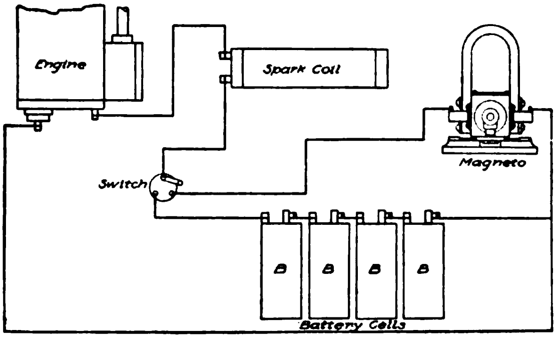


Fig. 80. Connections for Magneto System of Ignition. Magneto Current or Battery Current Using Same Spark-Coil.

The simplest magneto system is one which uses the same spark-coil for magneto and batteries. Fig. 80 shows the connections for this system.

The tendency at present in magneto ignition is divided between a low tension magneto and a step-up coil and the true high tension or Bosch type of magneto which generates its own high tension current. The former has no advantage over the high tension type except that of being cheaper. It has two disadvantages, namely, of producing a thinner spark and of having some magnetic lag at high speeds which is absent from the high tension type.

Fig. 81 is a diagram of this system as used by the National Motor Vehicle Company. The magneto has its own distributor or commutator attached to it; a magneto coil is placed in the same box as the storage battery; 1, 2, 3, and 4 are the lines to the spark-plugs in the four engine cylinders.

One pole of the magneto is grounded to the frame; and the other terminal comes out at the rear of the magneto on a copper brush, and is led by a cable through the switch on the dash (when thrown to the right), to the primary winding of the magneto coil, and from there through the circuit-breaker on front of magneto to ground on the frame, thus completing the primary or low-tension circuit of the magneto. The high-tension current goes from the secondary winding in the coil into the distributor on the magneto, whence it is distributed to the four spark-plugs.

The second system, which is the one for emergency and for starting the engine, consists of a three-cell six-volt storage battery; a single vibrator coil; a distributor or commutator, located on the vertical shaft at rear of engine; and the set of spark-plugs. In this system the current goes from the positive terminal of the battery (the negative terminal being grounded to the frame), through the primary winding and vibrator of the coil on dash, and from there through the circuit-breaker located in the bottom of the distributor, and thence to ground on engine. The high-tension current comes from the secondary winding of the battery coil to the distributor, whence it is distributed to the four spark-plugs. Each system has its own set of spark-plugs. To operate this system, the plug must be placed in the left hole in the battery coil. The

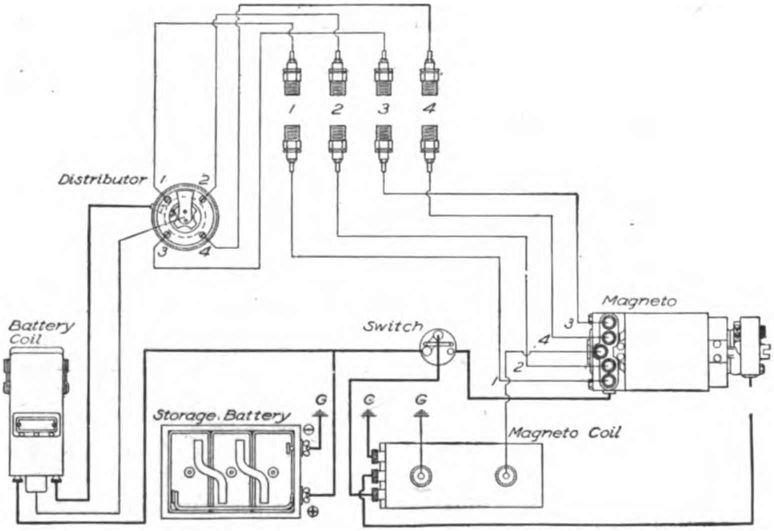
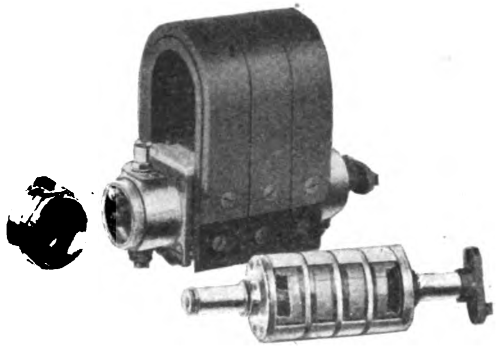


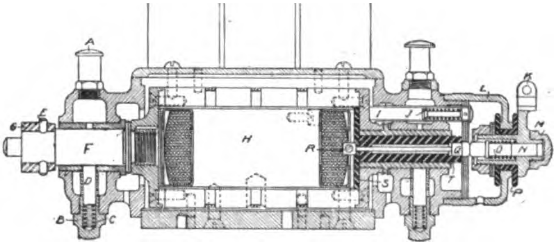
Fig. 81. Magneto, Spark-Coil, and Storage-Battery System of Ignition. National Motor Vehicle Company, Indianapolis, Ind.

same spark-lever controls the action of both systems. Ignition responds more instantaneously with the magneto system, so that it will appear to be timed ahead of the battery system.

The principal precaution to be observed in connection with the magneto, is to take care to prevent spattering of water on it when the car is being washed, to oil it carefully and regularly, and to see that none of its fastening screws become loose. Care should be taken to see that all wiring connections are tight, and that distributors are kept clean. Magneto brushes must not be flooded with oil, as they will become gummy and cause irregular firing.



Magneto of Locomobile Car. Armature Shown at Right, Withdrawn from Magneto. Bronze Cap at Left Encloses Contact End of Magneto.



Sectional View of Magneto (Magnets Only Partly Shown).

Fig. 82. Magneto and Parts as Used in Locomobile Car. *A*—Oiler; *B*—Bearing Oiler; *C*—Bearing Oiler Spring; *D*—Bearing Oiler Wick; *E*—Taper Pin Holding Coupling on Armature Shaft; *F*—Armature Shaft; *G*—Driving-Shaft Coupling; *H*—Armature; *I*—Brush; *J*—Brush Spring; *K*—Magneto Terminal; *L*—Bearing Cap; *M*—Contact Plunger Socket Cap; *N*-Contact Plunger; *O*—Plunger Spring; *P*—Bearing Cap Insulating Bushing; *Q*—Armature Contact Stud; *R*—Armature Terminal; *S*—Armature Flange Insulation Plate; *T*—Armature Shaft Insulation Bushing.

Locomobile Company of America, Bridgeport, Conn.

Fig. 82 shows in detail a typical magneto and its parts, as used in the Locomobile.

SPARK-PLUGS

The *spark-plug* consists simply of a receptacle for the purpose of bringing closely together the two exposed parts in the secondary line of the spark-coil, across which exposed parts it is proposed to have the spark take place. Inasmuch as the voltage, as already explained, is very high, the chief qualification of the spark-plug is that it must

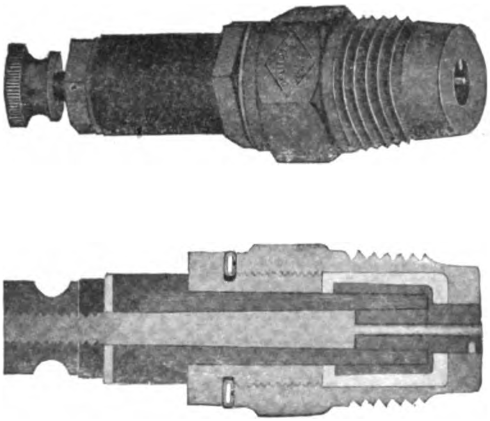


Fig. 83. Splitdorf Mica Spark-Plug.
The Splitdorf Laboratory, New York City.

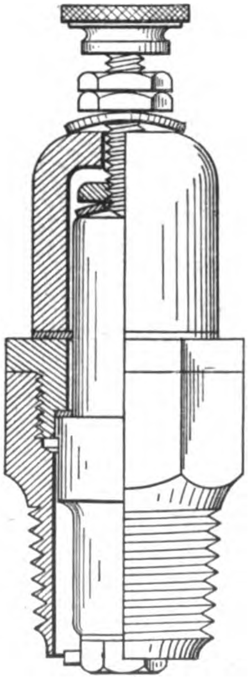


Fig. 84. Section of Sta-Rite Spark-Plug.
R. E. Hardy Company, New York, N. Y.

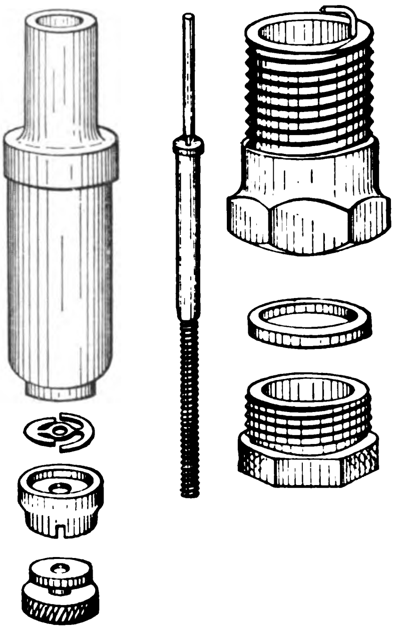


Fig. 85. Component Parts of a Soot-Proof Spark-Plug.
A. Mezgar, Brooklyn, N. Y.

have high insulating qualities so that the only possible path for the current will be across the gap. This means that the plug must be made of high-grade porcelain, and that the mica used in its insulation should be of the highest quality obtainable. The points should be platinum.

Fig. 83 gives an external and a sectional view of the Splitdorf mica spark-plug, made by the Splitdorf Laboratory, New York. Fig. 84 is a sectional view of a double porcelain separable plug, the Sta-Rite, made by the R. E. Hardy Company, New York. Fig. 85 shows all parts of the soot-proof plug made by A. Mezgar, Brooklyn, N. Y. The peculiar construction of the air-passages in this plug are such that it is claimed the plug may be blackened by holding it in the flame of a candle before placing in the cylinder, and after some use the blast in the cylinder will have cleaned off the soot.

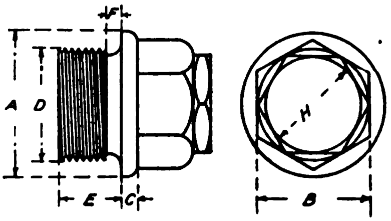


Fig. 86. Design and Dimensions of Standard Spark-Plug. Association of Licensed Automobile Manufacturers.
A—1⅛ in.; *B*—⅞ in.; *C*—⅛ in.; *D*—⅞ in.; *E*—Minimum, ½ in.; *F*—Maximum, ⅛ in.; *H*—¼ in.

Fig. 86 shows the standard dimensions for spark-plugs as adopted by the Association of Licensed Automobile Manufacturers.

It is always well to have an extra set of spark-plugs in the toolbox.

MAKE-AND-BREAK SYSTEM

The *Make-and-Break* system of ignition, which is the most prevalent in stationary gas-engine work, has recently come into favor in automobile practice. Fig 87 shows this system as used in the Studebaker car. In the make-and-break system, instead of using a spark-plug to provide the gap across which the spark jumps when high tension occurs in the secondary system as already explained, a rotating piece and spring are employed, these two pieces being in wiping contact during part of the time, and the contact being broken during a certain part of the time, owing to the shape of the rotating piece (which is clearly shown in the figure). The figure shows also the relative positions of the four make-and-break igniters at any one moment in a four-cylinder engine. The springs at the top of the igniters occasionally lose their tension, and may have to be replaced

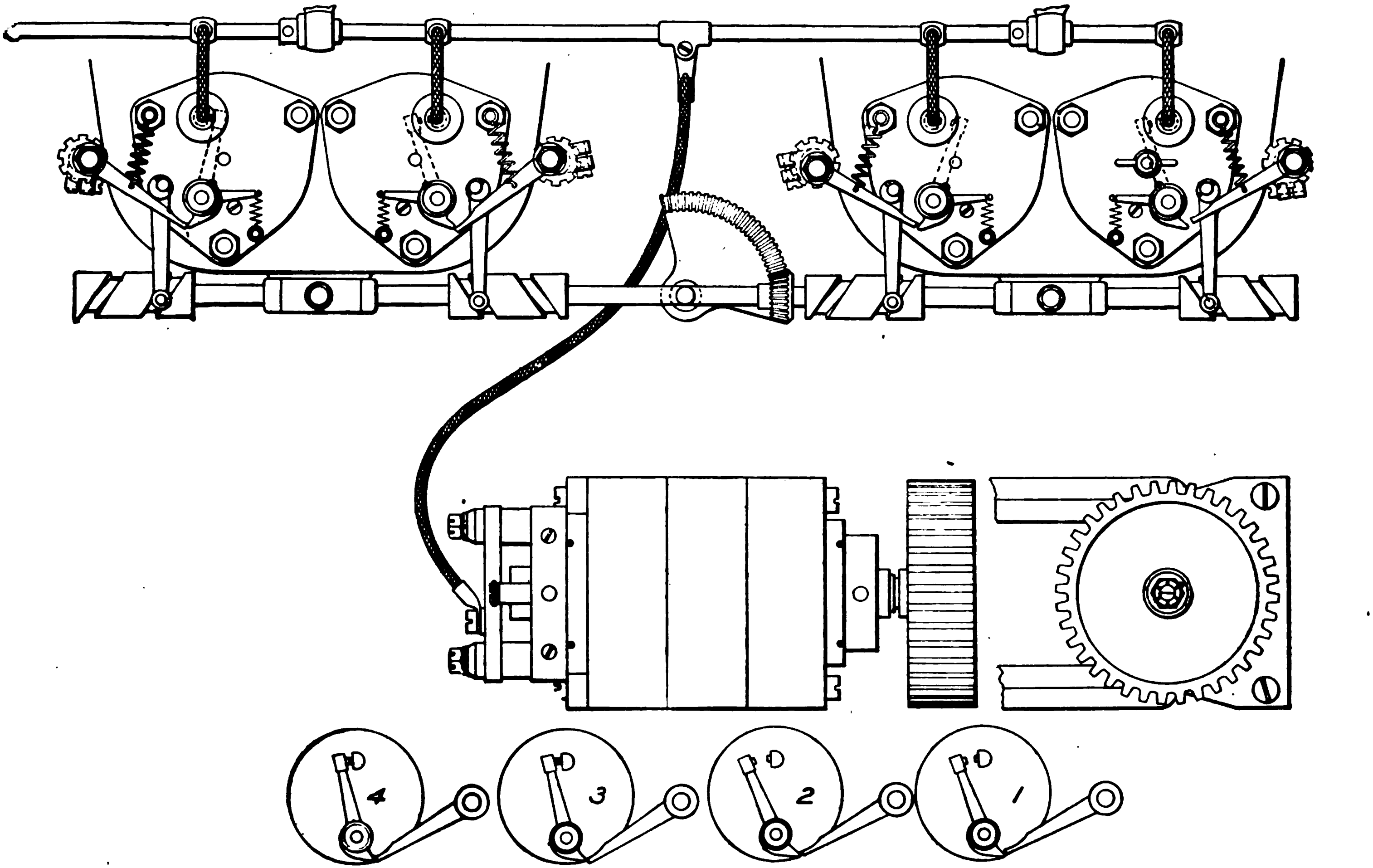


Fig. 87. Make-and-Break Ignition System as Used in Studebaker Four-Cylinder Car. Upper diagram shows but one igniter in contact, which is correct. Lower diagram shows igniters 3 and 4 short-circuited. Studebaker Brothers Manufacturing Company, South Bend, Ind.

or adjusted by turning the tension collar one or more holes and reinserting the cotter-pin.

After a month or so of continuous running, the contact-points at the bottom of the igniter and on the inside of the cylinder may become blackened. In this case it is advisable to remove the entire igniter-block, and soak it for ten or fifteen minutes in kerosene, after which it should be washed thoroughly. When replacing the block in the cylinder, always see that the external parts are carefully lubricated. It is well to remove the contact-blocks about once a month, and wash them as above described.

STORAGE BATTERIES FOR IGNITION PURPOSES WITH GASOLINE ENGINES

The most satisfactory current for charging storage batteries for ignition in gasoline engines, is one which can be supplied at a low voltage, as by means of dynamos specially designed for this purpose, so that it can be regulated at about the total voltage of the batteries to be charged—that is, in the neighborhood of six to eight volts.

To charge the batteries, it is necessary to raise the voltage of the dynamo to a greater value than that of the battery. If the voltage of the charging dynamo is less than that of the battery, the ammeter will indicate that a current is flowing, but the pointer will be drawn towards the left or in a backward direction, showing that the current is in an opposite direction from what it should be, and the battery is discharging through the dynamo.

If it is not practicable to secure the power by driving a low-voltage dynamo for charging the storage battery, it will be necessary to place some kind of a variable electrical resistance in the charging circuit, so as to prevent a destructive current from flowing, due to the higher voltage. For this purpose, incandescent lamps may be used, placed in the circuit in accordance with the diagrams, Fig. 88. The necessary number and capacity of the lamps depend on the voltage supplied and the current required. The diagrams indicate 16-candle-power lamps; with 32-candle-power lamps, twice as much current would flow through the batteries.

Sketch *A* shows a voltage of 110, each lamp used allowing one half-ampere to flow. Two lamps would mean one ampere; six lamps, three amperes; etc.

Sketches *B* and *C* are for 220 volts. Sketch *B* shows two 20-volt lamps, each allowing one quarter-ampere to flow. Sketch *C* shows 110-volt lamps with a line voltage of 220. In this sketch the lamps are connected in pairs, each pair taking one half-ampere.

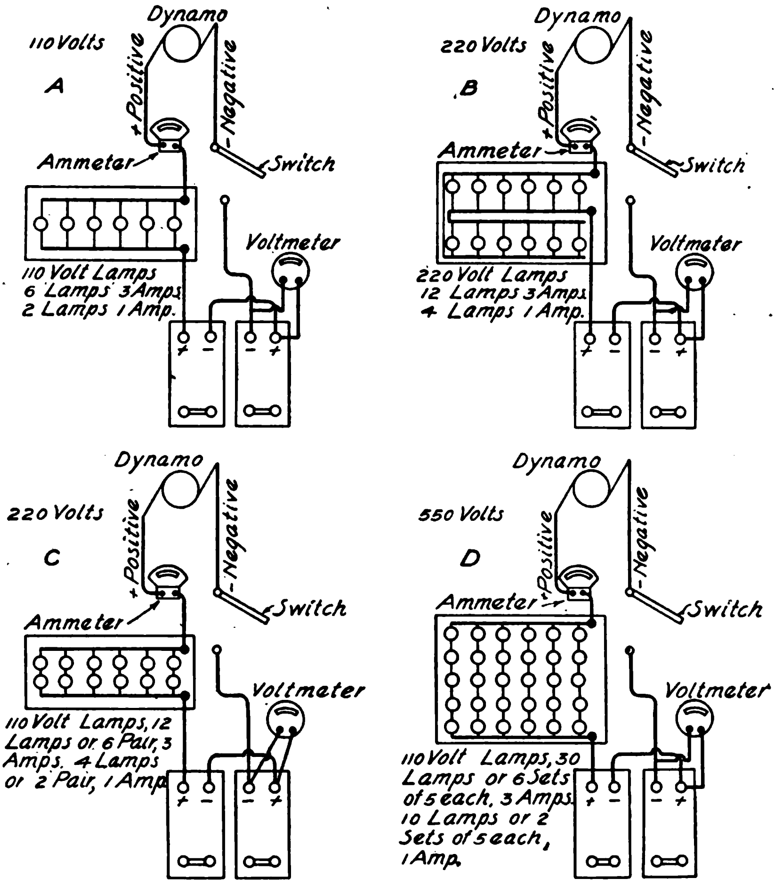
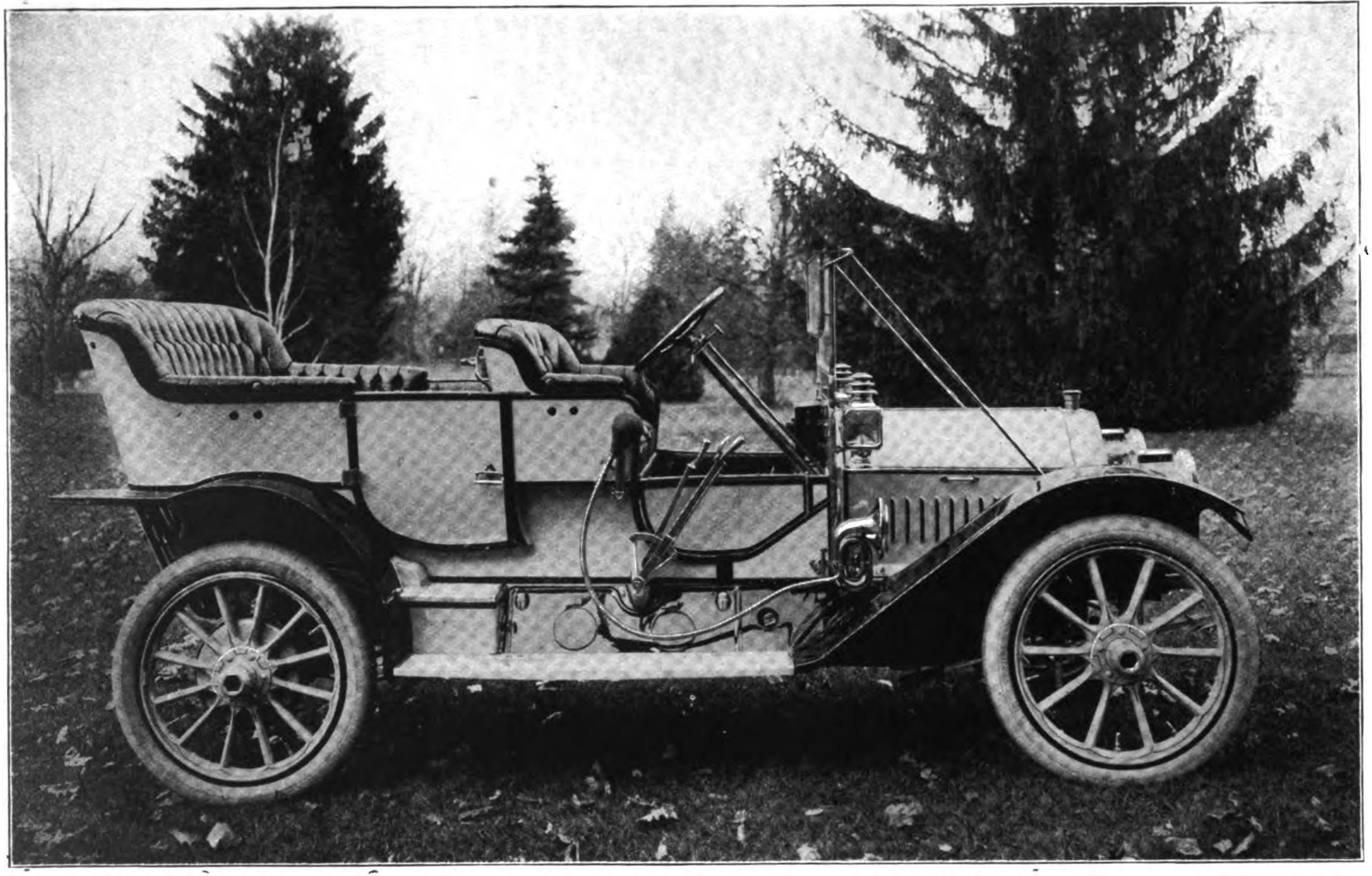


Fig. 88. Diagrams Showing Use of Incandescent Lamps as Variable Resistances in Charging Storage Batteries Used for Ignition Purposes with Gasoline Engines.

Sketch *D* shows connections for 550 volts. In this case five times as many lamps are needed as in *A*, connected in sets of five each, each set giving one half-ampere.

Only direct current can be used in charging storage batteries. *Be sure to connect the positive wire of the charging line with the positive terminal of the battery.* Otherwise, damage to the battery will result.



OLDSMOBILE TOURING CAR
Olds Motor Works, Lansing, Mich.

To determine which is the positive terminal of the charging line, attach a piece of lead to each wire of the line, and immerse the lead pieces in a glass containing diluted sulphuric acid, without touching each other. After the current has passed through the acid for a short time, the positive lead will commence to discolor and, after a while, will turn brown. Mark this wire plus (+), and connect it to the battery terminal marked plus (+), placing the resistance of lamps or other nature between the positive terminal of the charging line and the positive terminal of the battery. The voltage of the charging line should not be over twenty-five per cent greater than the discharge voltage of the battery—or, for a three-cell six-volt battery, about 7.5 volts. The indication that a battery is fully charged is *gasing* or fine boiling of the liquid electrolyte. Further instructions as to care of the storage battery will be found below, under the headings "Care and Operation of Electric Vehicles" and "Care of Storage Batteries."

ENGINE-CONTROLLING MECHANISM

Before attempting to drive the car, the new operator should become acquainted with the functions of the various levers and pedals. Of these, the ones that control the engine are the *Spark-Lever* and the *Throttle-Lever* or *Pedal*; also the *Compression-Release Pedal* and *Muffler Cut-Out.*

Spark-Lever. The spark-lever controls the time at which the electric spark occurs in the cylinders. Without a spark, there can be no ignition of gas in the cylinders, and no movement of the engine. The time at which the spark occurs is an important feature which is made use of in regulating the speed and power of the engine. The spark-lever is usually so placed that by moving it back toward the operator as far as it will go, it causes the spark to occur at a late period in the stroke; that is, the piston will have passed a considerable distance from the beginning of its stroke, and the crank a considerable angle past the dead center, when the charge is ignited. This action is called *retarding the spark.*

One effect of this late spark is to prevent any back-kicking, which would likely occur if the explosion took place near the dead center in an engine which had not yet attained any forward momentum.

Another effect is weak power and consequently low speed. The compressed charge has had opportunity to expand as it fills the increasing space back of the advancing piston; hence, when it is ignited, the pressure force due to the explosion will not be so great as when the ignited mixture is still more highly compressed. Moreover, the spark occurring late in the stroke means that the effective forward pressure effort is exerted during a lesser portion of the entire stroke than would be the case with an early spark.

Advancing the spark-lever advances the spark; that is, the spark occurs earlier in the stroke, and the speed is accelerated.

In addition to hand-regulation, *automatic regulation* of the spark is accomplished in some cars. The method employed is usually an automatic centrifugal or inertia governor, being in all mechanical respects a miniature steam-engine flywheel type of governor, which is mounted on the commutator-shaft and connected to the commutator so as to cause a later or retarded ignition if the speed increases too high. While in one sense such a spark controller is a convenience, it is looked on by many operators as an unnecessary refinement, and merely an additional piece of mechanism to take care of.

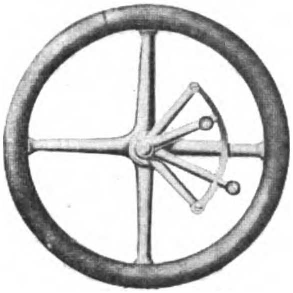


Fig. 89. Hand-Wheel, Showing Usual Location of Spark- and Throttle-Levers.

Location of Spark-Lever. In some cars the spark-lever is on the right of the driver's seat. In other cars it is on the steering column.

Fig. 89 is a view of the top of the hand-wheel, showing the most usual location of spark- and throttle-levers. Fig. 90 shows the steering column in section, and illustrates how the various concentric tubes which turn independently of each other are turned by means of these levers and in turn draw the rods regulating spark and throttle control.

Throttle-Lever. The throttle-lever is equally important with the spark-lever in acting as a governor or controlling lever, in regulating the speed and power of the engine. The throttle-lever is named by some makers the *controlling lever* or the *governor lever.* In some makes of car the throttle-lever is located on top of the steering wheel; in other makes the throttle-lever is operated by a foot-pedal or button; in still other makes a rod is connected to the throttling valve in such a manner that when the clutch is thrown out, throwing the load off the engine, the same movement closes the throttle, cutting off the supply of gas to the engine till it is just barely enough to keep it turning around. In cars in which such an automatic closing of the throttle is not provided, the operator must throttle his gas supply when he slows up or throws the load off the engine; otherwise the continuance of the full charge of gas into the cylinders will cause the engine to speed up or *race*. This racing is not beneficial to an engine, and must be avoided, either by releasing the foot-pedal which in some cars operates the throttle, or by moving the lever on the steering wheel which controls it in others.

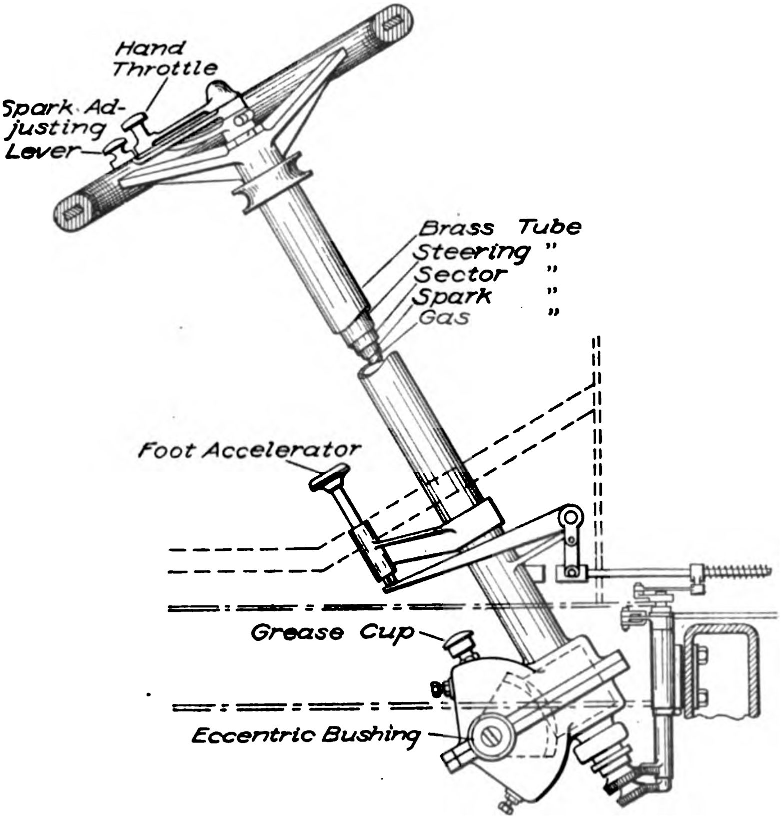


Fig. 90. Section of Steering Column, Showing Spark- and Throttle-Levers and Connections.

The throttle-lever usually connects to a butterfly valve located in the pipe-line running from the carbureter to the engine, this small butterfly valve enlarging or diminishing the passage from carbureter to engine cylinders, thus decreasing or increasing the supply of gas.

In starting, the amount of charge needs to be but small; hence the throttle-lever is in the position admitting only enough gas to turn the engine over.

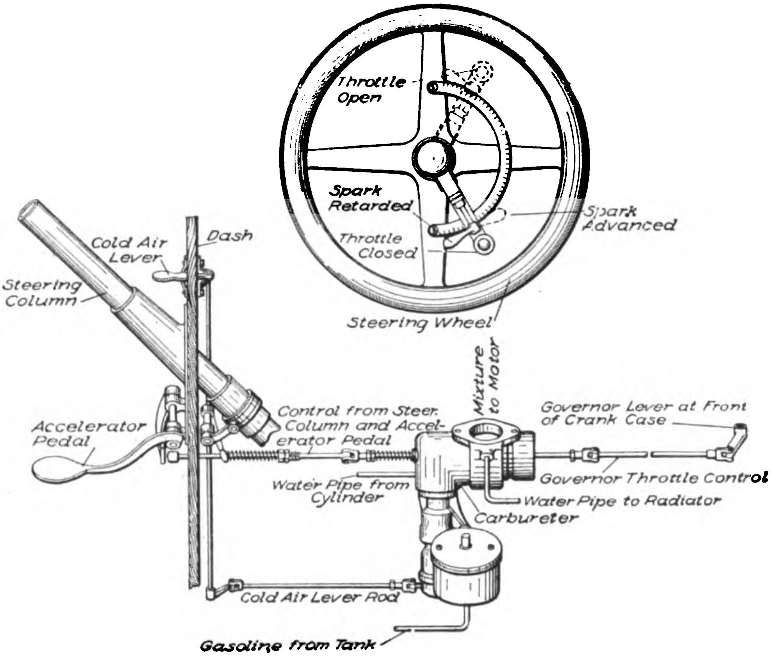


Fig. 91. Throttle-Control System of Peerless Car.
Peerless Motor Car Company, Cleveland, Ohio.

When shifting gears, the throttle should be momentarily closed, and the clutch entirely disengaged.

Just before stopping the engine, push the throttle-lever to the position in which it most completely closes the throttle valve.

In speeding up a car, advance the throttle first, and then follow with the spark.

Do not get in the habit of running the car with the throttle open and spark retarded. This results in over-heating of cylinders and valves, often causing exhaust valves to stick from over-heating and carbonizing, and resulting in excessive gasoline consumption. Keep the spark advanced in proportion to the speed of the car. However, watch carefully for any signs of knocking, which is occasioned by having the spark too far advanced, causing early explosion of the charge. This throws a heavy strain on the crank-shaft when passing dead center, and is likely to break the crank-shaft.

A novice is inclined to race his engine—to open his throttle too wide, giving too much charge without any load. He is apt to be afraid that if he checks down the throttle, he will have to get out and start the engine again. The result is that fuel is wasted and parts are worn out unnecessarily.

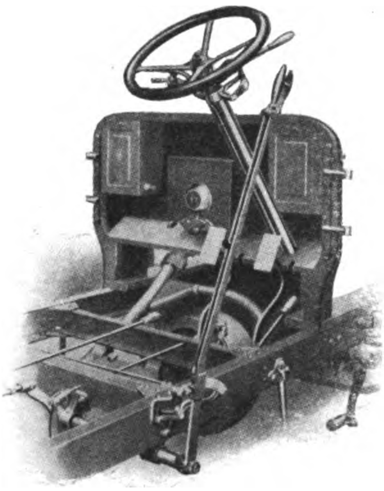


Fig. 92. Steering Column, Control Levers, and Emergency Brake of Great Arrow Car. George N. Pierce Company, Buffalo, N. Y.

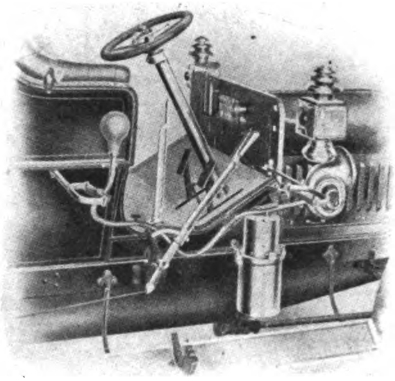


Fig. 93. Steering Column, Control Levers, and Other Operating Devices of Locomobile Car. Locomobile Company of America, Bridgeport, Conn.

Fig. 91 is a diagram showing a typical *throttle-control system* as used by the Peerless Motor Car Company. It will be noticed that the small throttle-lever on the steering column, and the *Accelerator* foot-pedal, operate the same rod, regulating the amount of mixture admitted to engine. A separate lever in this car regulates the amount of cold air admitted to the mixture.

Figs. 92 and 93 are other typical examples of engine-controlling mechanism.

Muffler Cut-Out and Compression-Relief Levers. In addition to the spark- and throttle-levers, most cars are provided with levers

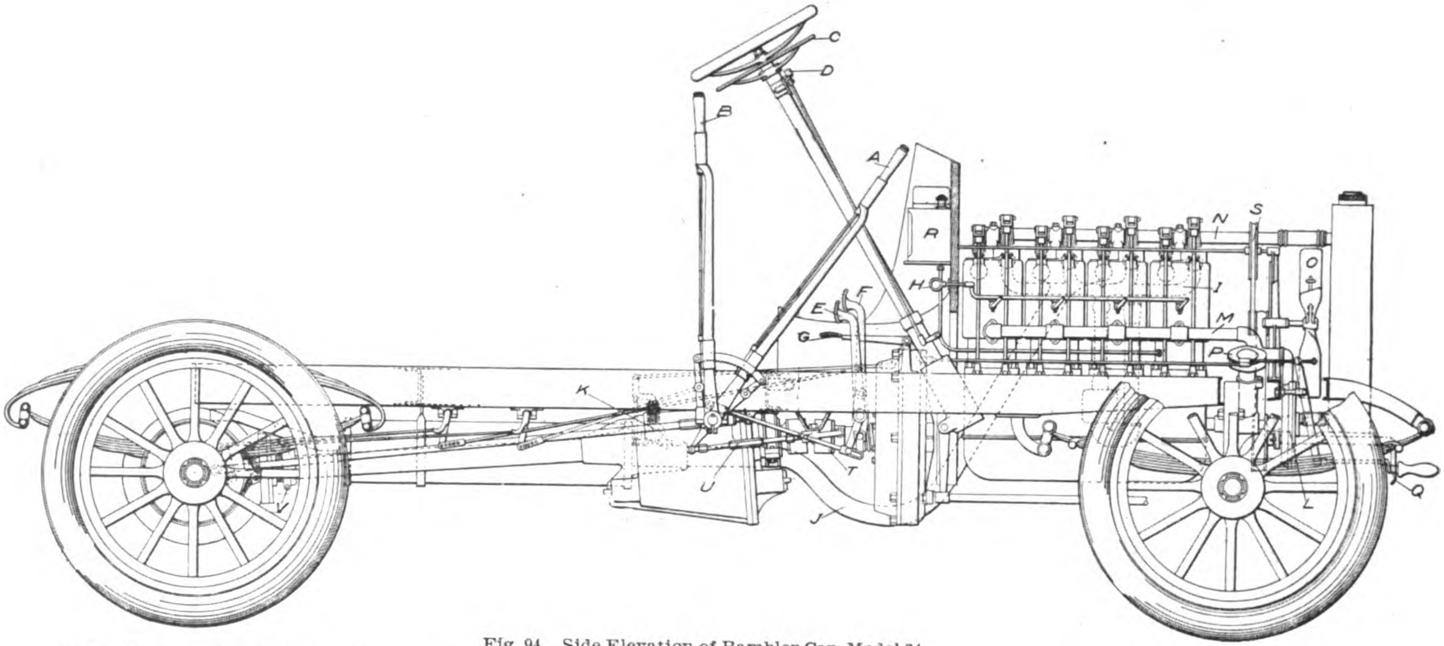


Fig. 94. Side Elevation of Rambler Car, Model 24.

A—Speed-Change Gear Lever; *B*—Emergency Brake Lever; *C*—Throttle Ring; *D*—Spark-Controlling Lever; *E*—Primary Brake Pedal; *F*—Clutch Release Pedal; *G*—Muffler Cut-Out Pedal; *H*—Pull-Rod for Opening Relief-Cocks; *I*—Inlet pipe; *J*—Exhaust Pipe; *K*—Muffler Cut-Out; *L*—Circulating Pump; *M*—Water Pipe from Pump to Cylinder Jackets; *N*—Water Pipe From Jackets to Radiator; *O*—Fan; *P*—Commutator; *Q*—Safety Crank Latch; *R*—Oiler; *S*—Pulley and Driving Rod for Operating Oiler; *T*—Universal Joint between Clutch and Transmission Gear; *U*—Gear-Shifting Connections; *V*—Bearing Adjustment at Rear End of Propeller Shaft.

for opening the exhaust into the air without passing through the muffler. This is a means of gaining more power, and is utilized in going up grades and when power is at low ebb.

The compression-relief rod connects to cocks on the engine cylinders, preventing or partially preventing compression. The chief use of this rod is in starting, to permit of easy cranking. The compression-relief rod, instead of operating independent relief-cocks, is frequently connected to cams or rollers which raise the exhaust valves.

Fig. 94 is a side elevation of Model 24 Rambler Car, which shows very clearly the location and action of the muffler cut-out and compression-relief levers. In this diagram, *G* is the muffler cut-out pedal, which connects to *K*, the muffler cut-out; and *H* is the pull-rod for opening the cylinder compression-relief cocks.

POWER-TRANSMISSION DEVICES

Thus far we have considered the frame, the running gear, the engine, and the methods used for operating and controlling the engine. The next logical step in our analysis of the car into its component parts, is a study of the methods of transmitting the engine power at its various speeds to the running gear. This leads us to a study of *Power-Transmission Systems.*

The power-transmission system consists (1) of the *Clutch* and its operating rods and levers for connecting the engine to the speed-changing or transmission system; (2) of the *Transmission* or *Change-Speed Gears,* which transmit the power of the engine to the *Differential System,* which last-named transmits the power from the change-speed gears to the rear axle of the car. The Clutch System and the Transmission or Change-Speed System each include a set of operating rods and levers, the action of each of which must be thoroughly understood by the operator before he attempts to drive his car.

CLUTCHES

Metallic Constriction-Band Clutches. Most runabouts having horizontal engines use what is known as the *constriction-band* type of clutch in connection with *planetary transmission.* The various speeds are given from the engine to a countershaft or an external hollow shaft carrying a sprocket wheel over which passes a chain driving a larger sprocket on the rear axle. These various speeds are secured in the following manner:

A series of rods or clutch fingers are attached to a collar on a countershaft in such a manner that they may be operated to and fro by means of a lever located at the driver's right hand, which is known as the *clutch lever*. In this type of transmission, high speed is secured by locking all of the transmission gearing together so that it revolves with the motor shaft and acts as an additional fly-wheel carrying with it the driving sprocket. In the neutral position, the clutch fingers are altogether released, leaving the motor free to run without driving the automobile.

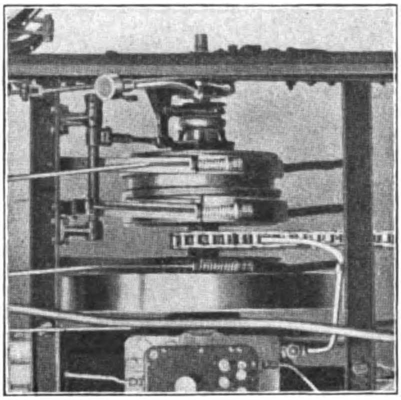


Fig. 95. Constriction-Band Clutch, as Used in Reo Car.
Reo Motor Car Company, Lansing, Mich.

The constriction bands are used to hold the large ring gears with internal teeth, which constitute the outer periphery, from turning while the internal smaller pinions roll around inside at a speed such that the sprocket is driven at about one-third or one-fourth that of the engine shaft. The mounting and meshing of the various gears are arranged so that the tightening of one constriction band causes slow speed forward, and of the other constriction band causes slow speed backward. In a good many vehicles of the runabout type, the reverse feature is separately connected to a foot-pedal.

Oil should not be put on metal band clutches unless there is evidence of cutting, as it will cause them to slip. The wearing surfaces of the bands should be wiped with gasoline occasionally, to help keep them smooth and clean.

It is seldom necessary to tighten the clutch bands, and it is usually a mistake to tighten them, as this is likely to cause them to break.

Fig. 95 shows an external view of a typical constriction-band clutch as used with planetary transmission in the Reo car.

Fig. 96 shows the planetary transmission of the Reo car, with the rods attached to the clutches. It will be noted that the reversing clutch has its rod connected to a foot-pedal, and the two forward speed clutches are operated by the side lever on the outside of the frame

Planetary transmissions have the clutches and their levers so arranged as to give two speeds forward and one reverse, in almost all instances.

The arrangement of the gears and their action in the planetary transmission system are more fully described under the heading of "Speed-Changing Gears."

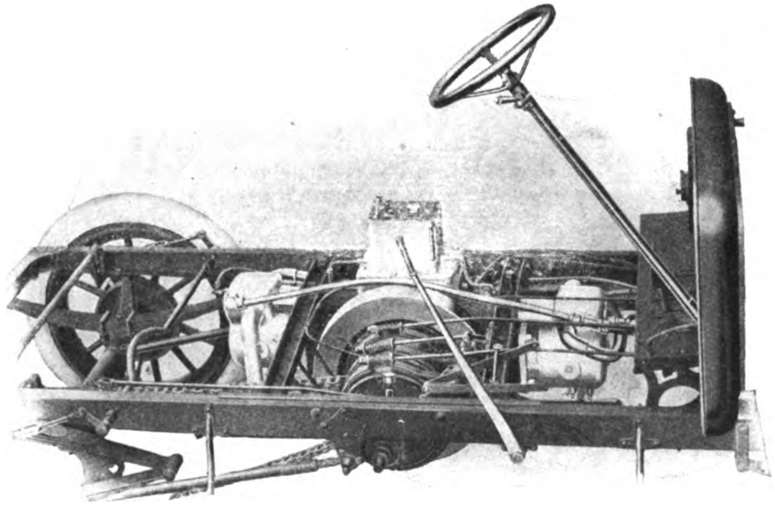


Fig. 96. Side View of Part of Chassis of Reo Car, Showing Constriction-Band Clutches and Operating Rods.
Reo Motor Car Company, Lansing, Mich.

Disc Clutches. With vertical automobile engines, the friction clutch is most generally a single disc in the form of a frustum or section of a cone, with a face several inches in diameter; or a series of flat discs. The disc or discs are either pushed into the fly-wheel (which has a corresponding hollowed-out portion) from the rear towards the front of the car, or are pulled into the fly-wheel towards the back on the squared portion of a coupling shaft between the engine and transmission. In this manner the rotation of the engine fly-wheel is transmitted to the shaft on which the clutch disc or discs are keyed. This clutch shaft is in turn connected to the so-called

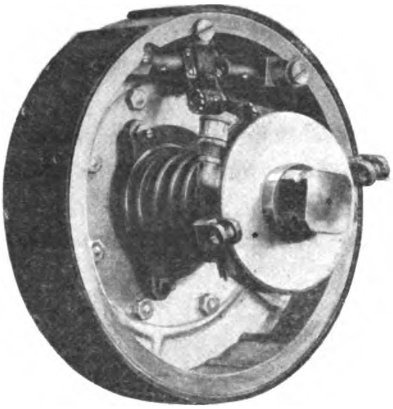


Fig. 97. Internal Expanding Clutch. Peerless Motor Car Company, Cleveland, Ohio.

transmission or speed-changing system, which connects to the rear or driving wheels.

The clutch is most frequently operated by means of a *push-pedal.* In some cars it is necessary to keep a downward pressure on the pedal, either with the foot or by means of a latching device, in order to keep the clutch in contact with the fly-wheel. In this type of construction, a stiff spring normally pulls the clutch out of engagement, the pull of the spring being overcome by the pressure on the pedal.

Another type of construction is one in which a forward pressure on the push-pedal disengages the clutch from the fly-wheel and prevents the transmission of power from the engine to the transmission.

It is a very general mistake to consider it as part of the regular oiling of an automobile to oil the leather face of the clutch. If the clutch is operating satisfactorily, it should not be disturbed. If it slips, it needs attention. Slipping of the clutch is caused by its

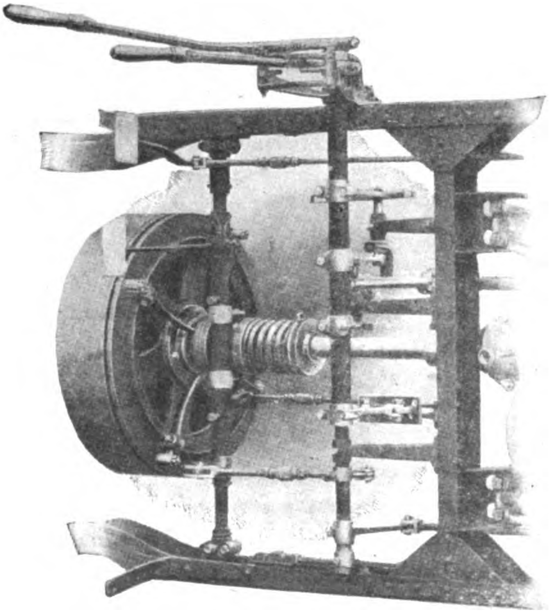


Fig. 98. Thomas Patented Three-Disc Clutch with Cork Inserts in Position on Chassis of Thomas Car. E. R. Thomas Motor Company, Buffalo, N. Y.

being too greasy and hardened by dirt. The remedy is to clean the leather with gasoline and then treat it with castor oil, spreading the oil all around, and allowing it to soak over night in order to make it soft and pliable.

In some cars the pliability of the clutch leather is increased by having grooves milled or chipped into the aluminum body of the disc, and placing short pieces of flat spring steel with a slight outward curvature in these slots. The outward pressure against the leather band, which, although riveted or stitched to the disc, is attached in such a manner as to be susceptible to this outward action of the spring steel, makes it very easy to engage the clutch gradually and without sudden gripping. A novice is inclined to throw the clutch in too suddenly.

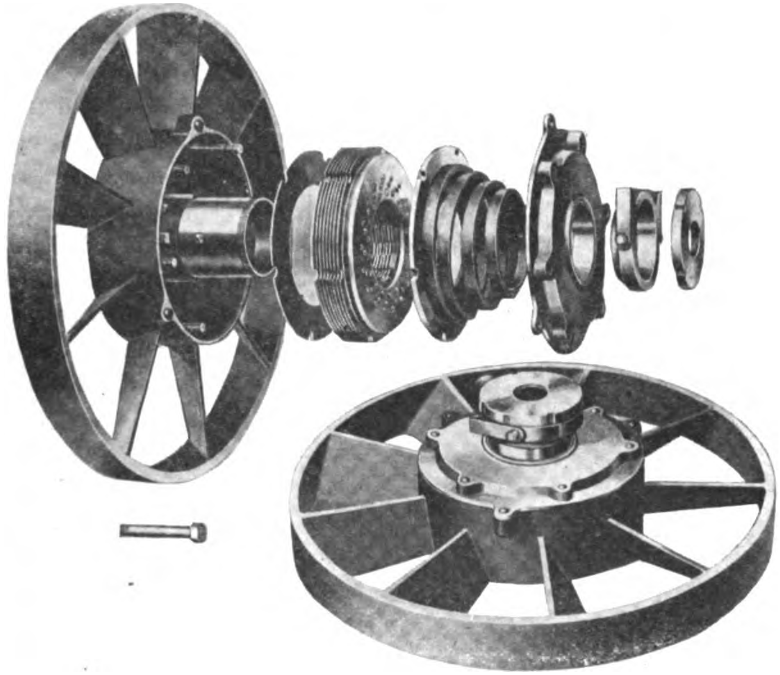


Fig. 99. Multiple-Disc Clutch of the Franklin Car.
H. H. Franklin Manufacturing Company, Syracuse, N. Y.

Fig. 97 shows a conical leather-faced disc clutch as used in the Peerless car; and Fig. 98 shows a similar clutch as used in the Thomas car, mounted in position on the chassis.

Recently *multiple-disc clutches* have been superseding the leather-faced cone clutches, owing to the fact that the leather wears out pretty rapidly, and also the multiple discs can be put into small space and encased in oil. Fig. 99 shows this type of clutch as used in the Franklin car. The disc clutch is located within the fly-wheel. The discs are of phosphor-bronze and steel alternated, and run in an oil bath. The bronze discs revolve with the fly-wheel; the steel discs revolve with the clutch-driver. None of the discs can revolve independently, but they are free to slide together or apart; and when the clutch is let in, a spiral spring squeezes them together. As the oil between them is squeezed out, the bronze discs turned by the fly-wheel press against the steel discs on the clutch-driver, which is connected to the transmission shaft, and gradually revolve them by friction. This revolves the transmission shaft, and the car gradually starts.

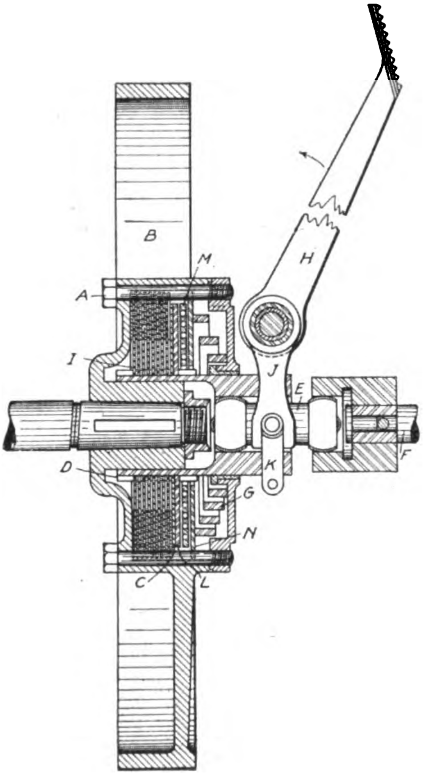


Fig. 100. Diagram Showing Construction of Franklin Multiple-Disc Clutch.
H. H. Franklin Mfg. Co., Syracuse, N. Y.

This clutch is further illustrated diagrammatically in Fig. 100. The bolts *A* prevent the phosphor-bronze discs from rotating in the fly-wheel *B*, but the discs are free to move laterally The steel discs *C* do not touch the fly-wheel, but are carried on the clutch-driver *D*, on which they are free to move laterally, but can rotate only with the clutch-driver The clutch-driver, by means of the universal block *E*, is connected directly to the transmission shaft *F*.

The flat spiral spring *G* holds the plates firmly against each other when the clutch is engaged or whenever the foot-lever *H* is not pressed forward.

As the motor turns, it revolves the fly-wheel *B*; the discs *I* also revolve, being driven by bolts *A*. Because of the spring *G*, friction is exerted on the discs *I* and *C*, and the discs *C* are thus made to revolve. This rotates the clutch-driver *D*, because the discs *C* are fastened to it. The rotation of the clutch-driver *D* is communicated to the transmission by the square driving block *E*.

To throw out the clutch, the foot-lever *H* is pressed forward. This moves the clutch-shifter lever *J* backward, which carries with it the clutch-shifter trunnion *K*, which runs upon the clutch-driver *D*. As the clutch-driver *D* moves backward, it brings with it the ball thrust represented by *L, M*, and *N*. This compresses the spring *G*, relieving the pressure on the discs, which, being free to move laterally, separate; and oil, from the oil bath in which the clutch runs, fills up the spaces between the plates. When the clutch is released, the oil which has gotten in between the plates is released by pressure. While the oil is being removed, the clutch slips slightly and the car picks up gradually.

SPEED-CHANGING GEARS

Planetary Gears. The operation of constriction-band clutches used in connection with planetary gears has already been touched upon under the heading of "Clutches."

Fig. 101 is a view of a typical planetary gear set, as used in the Cadillac car. In this figure, the central gear *D* is the driving gear, and is keyed to the engine shaft. This drive gear meshes with the planetary pinions *F F F*, which in turn mesh with the internal gear *B*.

The driving sprocket and its frame are mounted on a journal which rotates freely about the engine shaft, either at the same speed forward as the engine shaft, or at slower speed forward, or at a slow speed in the reverse direction. The speed and direction of the sprocket depend on the operation of the clutches. If the lever is drawn which is attached to the high-speed clutch, the drum *K* becomes locked to the engine shaft. All of the gears are then inactive, and the entire gear set rotates as an additional fly-wheel, the sprocket turning at the same speed as the engine shaft.

For slow speed the drum *K* is held by the tightening of the slow-speed clutch band, preventing the drum from rotating. The planetary pinions, rolling on the internal gear *B*, drive the same slowly forward, and with it the sprocket *A*.

For reverse, the case *H* is held by its constriction band; and gear *B* is now driven in the opposite direction from the engine shaft, and with it the sprocket *A*.

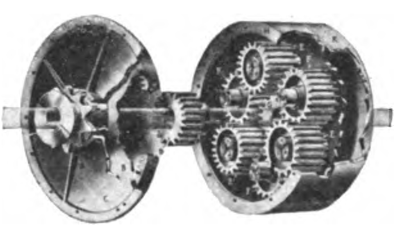


Fig. 101. Planetary Transmission Gear of Cadillac Single-Cylinder Car.
Cadillac Motor Car Company, Detroit, Mich.

Sliding Gears. The sliding-gear type of speed-changing device is by far the most generally used, particularly on touring cars and heavier cars in general.

The sliding-gear set consists of two sets of gears—one set mounted on a shaft to which they are rigidly fastened; and the other set mounted on a countershaft, which is either square between its journals, or with a long key so that the gears on it may be moved lengthwise along the countershaft and made to mesh in different combinations with the gears that are fixed in position on the main shaft.

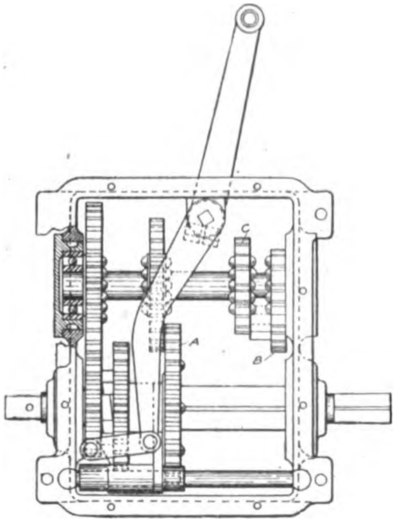


Fig. 102. Sliding Transmission Gear of Franklin Car.
H. H. Franklin Mfg. Co., Syracuse, N. Y.

The operation of the sliding-gear set on any car can be easily learned by removing the gear-box cover and moving the gear-shifting levers, watching the resulting gear meshings.

Fig. 102 shows the sliding-gear set of the Franklin car. The cut shows the position of the gears for direct drive, or high-speed gear. For reversing, gears *A* and *B* are in mesh. For low speed, gears *A* and *C* are in mesh.

Fig. 103 is another example of a sliding-gear set as used in the Autocar. The shaft *A* is the main drive shaft, on which the clutch is mounted. Gears *B* and *C* are practically one piece, and are carried along the squared shaft *D* by a sliding fork connected by rods to the gear-shifting lever (this fork is not shown in the illustration). Shaft *A* is separate from shaft *D*; that is, they can revolve at different speeds. For the slowest speed, the slide gear *BC* is moved along the squared shaft until *C* is in mesh with *E*. For the reverse, *C* meshes with an idler connected with *F*. For the intermediate speed, *B* meshes with *G*. For high speed or direct drive, the teeth *H* engage with the teeth *K*, and *D* rotates at the same speed as the engine shaft. At all times *L* is in mesh with *M*, and so drives the countershaft *N*. At the rear end of *D*, is the universal joint connecting the gear set with the rear axle.

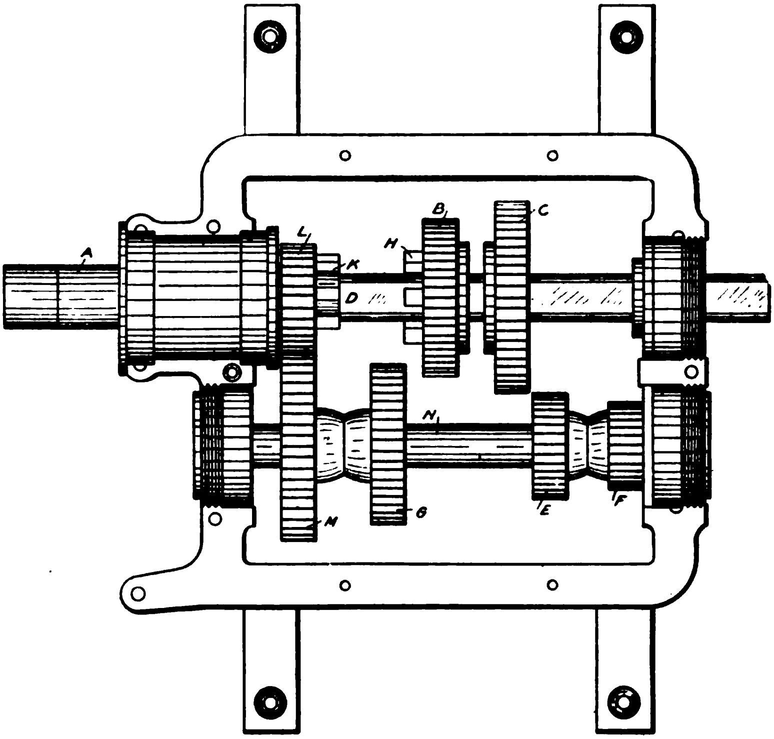


Fig. 103. Sliding-Gear Set of Autocar.
Autocar Company, Ardmore, Pa.

All modern cars that use sliding-gear sets are provided with some arrangement whereby the clutch is disengaged during the gear-shifting process, in order to prevent grinding of gears during changes.

Speed-Changing Levers Operating Sliding Gears. Some cars have separate levers for high and low speed. Some use a lever for high speed, and a foot-pedal for slow speed; and in such cars the operator must be careful never to throw the high-speed lever forward before the low-speed lever is released, or *vice versâ*.

Some makers use a single speed-changing lever on the right side of the car, usually nearer the operator than the brake lever, which is generally the outside lever where there are two levers on the right side of the car. With this variety of speed-changing lever, there is usually a piece in the form of a quadrant or arc of a circle located near the lower part of the lever. This quadrant is provided with notches that catch a pawl with a spring back of it, which is compressed and consequently released by the hand pressing on a grip operating a rod leading to the spring. These notches or steps are located at the points for proper meshing of gears, or of tightening of clutch-bands for the various speeds.

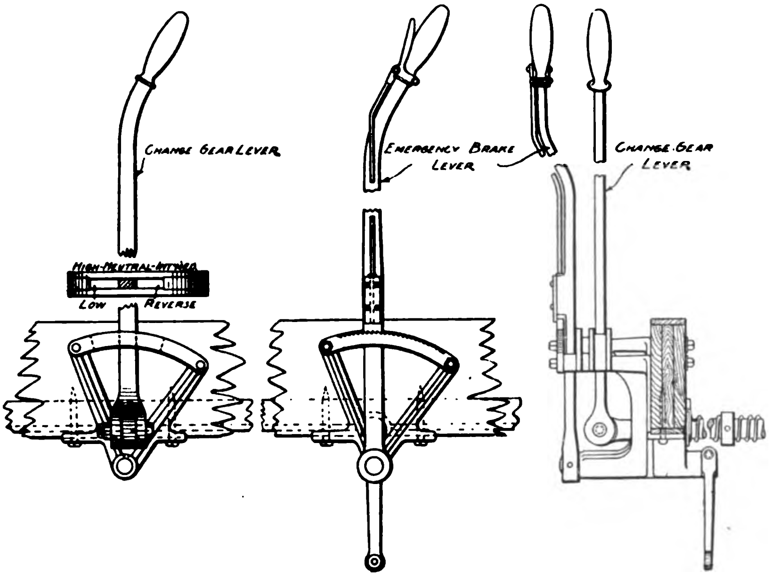
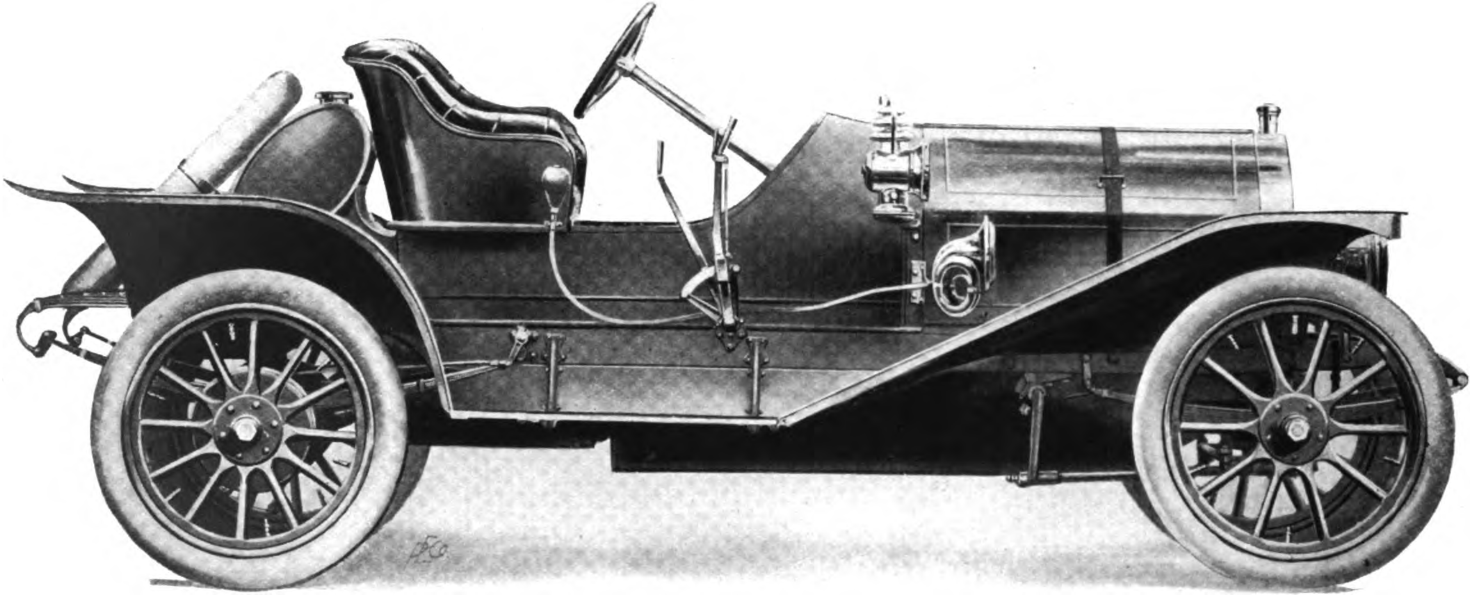


Fig. 104. Emergency Brake and Change-Gear Control.
H. H. Franklin Manufacturing Company, Syracuse, N. Y.

A still further range in a limited space is obtained in the Thomas, Franklin, Peerless, and other cars, by means of a lateral movement of the speed-changing lever so that it has two paths in



CHALMERS "FORTY" SPECIAL SPEED RACER
The Chalmers Motor Co., Detroit, Mich.

the quadrant—an inner and an outer path—each path provided with notches.

Fig. 104 shows this type of lever and quadrant as used in the Franklin car; and Fig. 105 shows a similar set as used in the Peerless car. Referring to Fig. 105, it will be seen that the lever can be thrown into five notches. When the lever is in neutral position between the notches, none of the gears are meshed, and the motor runs free.

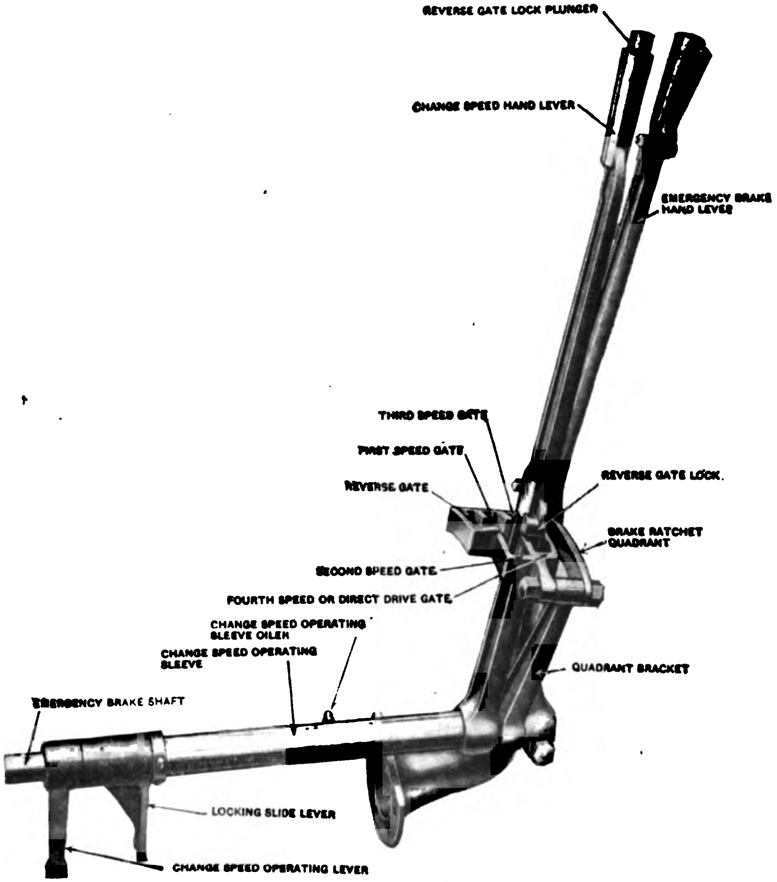


Fig. 105. Speed-Changing and Brake Levers of Peerless Car.
Peerless Motor Car Company, Cleveland, Ohio.

In the first speed, the driving is through the direct-drive sleeve countershaft gear, first-speed pinion, and first-speed gear (see Fig

106, which shows the sliding gears of the Peerless car). Second speed is through direct-drive sleeve, countershaft gear, second-speed pinion, and second-speed gear. Third speed is through direct-drive sleeve, countershaft gear, third-speed pinion, and third-speed gear. High speed is through direct-drive gear meshing internally with third-speed gear, thus making a direct drive.

For the reverse, the driving is through the countershaft pinion, countershaft gear, first-speed pinion, and reverse idler gear that reverses first-speed gear.

The most desirable arrangement for direction of lever movement for reverse, is one in which the lever must be pushed backward from neutral notch towards the rear of the car, as this seems the natural movement to produce *backing up.*

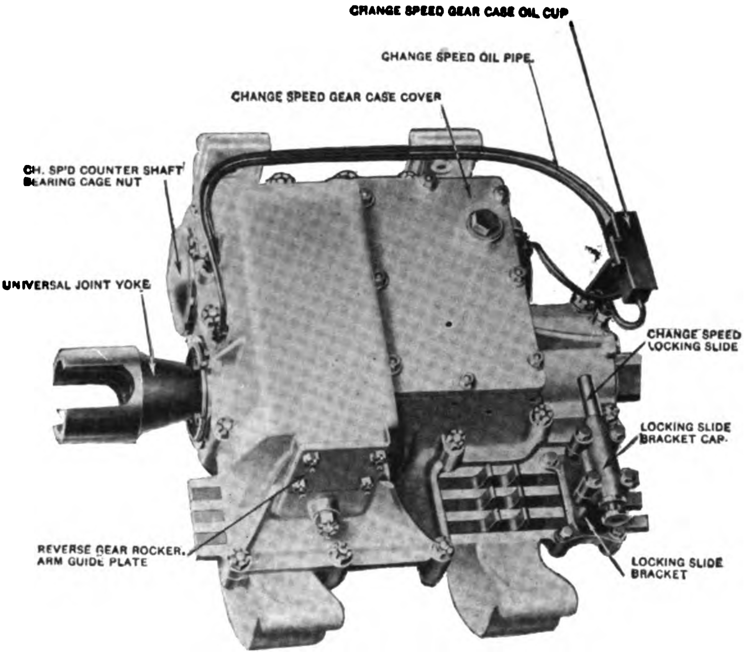
Use of Speed-Changing Levers in Operating Car. Before pushing lever into high gear, start on low gear, then throw into middle gear, and then into high speed.

To stop the car, disengage the clutch where the clutch is operated by a foot-pedal separate from the hand-levers. This plan is advocated because it facilitates quick stopping. Remember, however, that you have not "finished your job" until the speed lever has been thrown into "neutral" or "off" position. You are likely to forget this, although remembering the other details in regard to stopping your engine, with the result that when you throw in the clutch you start off on high speed.

In cars where a foot-pedal throws in the clutch, be sure that the speed-selecting lever is fully in position for proper meshing before the clutch pedal is let into connection; otherwise the gear teeth may be only partly in mesh, and the sudden strains of starting would be liable to damage the gears.

CAUTION. *Engage but one gear at a time.* A serious chance for confusion and breakage is offered the operator in makes of cars employing separate levers, by the fact that in some cars the slow-speed lever is used as a reverse lever by pushing it into its extreme forward position, instead of by adopting the suggestive and natural method of accomplishing reverse by a backward throw of the lever.

In all cars employing two levers for speed changes, be absolutely sure that one lever is thrown into neutral position before the


CHANGE SPEED GEAR CASE OIL CUP
CHANGE SPEED OIL PIPE
CHANGE SPEED GEAR CASE COVER
CH. SP'D COUNTER SHAFT BEARING CAGE NUT
UNIVERSAL JOINT YOKE
CHANGE SPEED LOCKING SLIDE
LOCKING SLIDE BRACKET CAP
REVERSE GEAR ROCKER ARM GUIDE PLATE
LOCKING SLIDE BRACKET

Speed-Changing Gear Set, in Case.

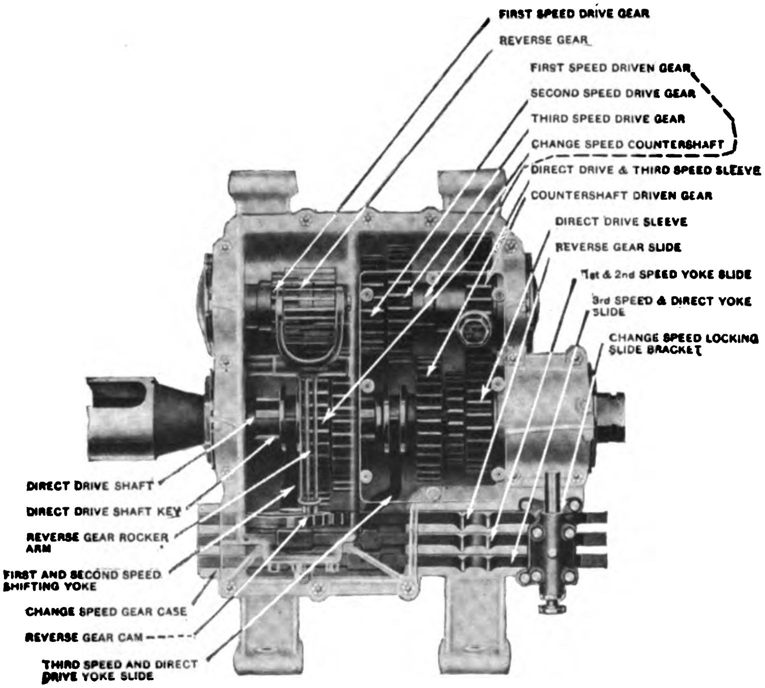


Fig. 106. Speed-Changing Gear Set, Cover Removed.
Speed-Changing Gear of Peerless Car.
Peerless Motor Car Company, Cleveland, Ohio

other is engaged. The neutral position would naturally be the center of the arc or quadrant; but here again different makers differ.

Although some cars are so constructed that the meshing of one lever *locks*, or prevents any other lever from being thrown into mesh, there are many makes of car which are not "fool-proof" in this respect. A novice, thinking he has to put on his slow speed before reversing, and then put on his reverse, is liable to damage something in some makes of cars where he can put both in mesh at the same time.

Changing Gears. A driver will soon become familiar with the approximate speed corresponding to each set of gears, especially if he compares the speed as he sees and feels it with the odometer readings. In changing gears, the car should first be brought by means of the spark and throttle regulation to very nearly the speed of the gear to which it is desired to change.

In changing from low to high, the movement on the gear lever should be quick, so that meshing of the teeth is done promptly without any grating. In changing from high to low, the movement does not need to be so rapid.

Difficulty in Changing Gears. If there is difficulty or noise in changing gears, it is likely to be due to worn or loose bearings, or loose pinions, or loosening of the gear case. A new car should not be accepted if there is difficulty or noise in changing gears, although this feature is neglected by many makers.

Grinding Gears. Occasionally a car is found which gives the operator considerable trouble in changing from one gear to another, owing to the gears grinding together instead of going into mesh easily. If this trouble appears by degrees in a car ordinarily well-behaved, it is a pretty sure indication that the gear-shaft bearings have been cut so that the shafts are badly out of line, and trouble of this sort should be investigated at once, as nothing will wear the gears so fast as to mesh improperly.

Running on High-Speed Gear. Where there are three speeds, the highest speed is usually the direct. In some instances where there are four speeds, the third is the direct. It is generally considered best to keep on the direct-drive gear as much as possible, because it gives less heating, and there is less friction in engine and transmission and less lost work. When the engine speed gets so low that the strain is felt in each stroke in the parts, it is best to change to lower gear.

The prevalent fad of climbing all hills on the high-speed gear is a great mistake. Although it may be possible to force a car up a hill on this gear, the time taken will be as a rule just as long as if the lower gear had been used, and the strain on the engine and transmission is unnecessarily great.

DRIVE

The clutch and clutch-shaft constitute the connecting portion between the engine and the speed-changing or transmission systems. The term *transmission*, in its general sense, includes also the connections between the transmission or speed-changing gears and the rear-axle driving system. The prevailing types of transmission from the gears to the rear system, and generally designated by the term *drive*, are:

1. Single-Chain Drive.
2. Double-Chain Drive.
3. Direct or Shaft Drive.
4. Friction Drive.
5. Cable Drive.

It is claimed that the single-chain drive is more efficient than either the shaft or double-chain drive. However, a single-chain system necessitates the hanging of the engine lengthwise with the chain, or the use of an extremely long chain extending to an engine under a hood.

The shaft drive is generally acknowledged to be more efficient than the double-chain drive, because there are fewer points of friction. The shaft drive eliminates two bearings, besides doing away with both chains and four sprocket-wheels.

The direct drive requires the use of one or two universal joints to provide for any change in alignment between the clutch-shaft and the rear-axle drive-shaft. The *universal joint* has been a part of automobile mechanism that has caused a great deal of trouble to manufacturers whose design of joint has not been liberally and accurately proportioned and made of the best material. These difficulties have been overcome as designs of universal joints have improved; and for several years, every Vanderbilt race has been won with a shaft-

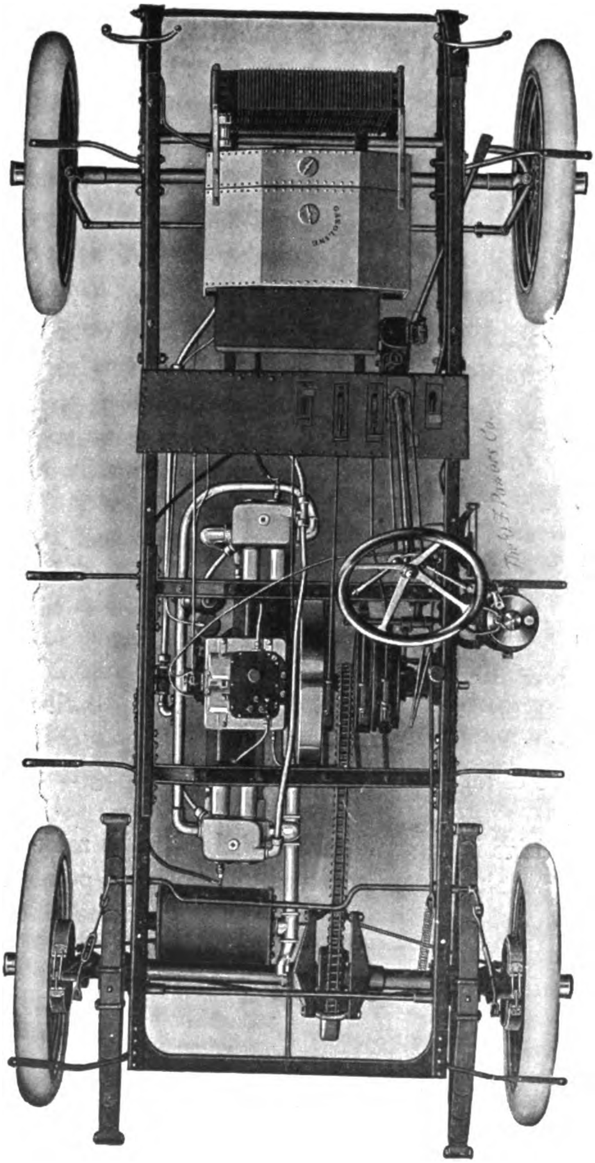


Fig. 107. Chassis of Reo Two-Cylinder Car, Single-Chain Drive. Showing how motor is placed in frame, and power transmitted from engine to rear wheels. Reo Motor Car Company, Lansing, Mich.

driven car. The shaft drive can be made dust-proof, which cannot be said of the chain drive. The chain drive is much more exposed to dust, and has many more wearing parts.

Still another type of transmission is the so-called *friction* transmission. In this system, a disc of from 18 to 30 inches diameter is keyed to the rear end of the clutch-shaft. Its rotation is transmitted by means of an intermediate disc placed at right angles to the first one, and through it to a third disc parallel to the first and keyed to the drive-shaft. The intermediate disc or cone—or set of them, there being sometimes two—is arranged so that it can be drawn outward or pushed inward, the rim thus bearing on the face of the disc mounted on the clutch-shaft, at varying radial distances from its center. As the bearing surface is drawn further out, the rotational speed is increased. This type of transmission is being applied to an increasing number of medium-weight and light-weight cars.

Fig. 107 is a view of the Reo car chassis, showing a good form of single-chain drive.

Fig. 108 shows a double-chain drive as used in the American Locomotive car.

Fig. 109 is a view of the Studebaker Model "L" chassis, showing direct-drive shaft with two universal joints.

Fig. 110 is a view of a two-disc friction transmission with single-chain drive, as used in the Cartercar.

Cable drive is employed in the Holsman car, the cable passing over sheave wheels, a small one on the drive-shaft and a large one on the axle.

Universal Joints. Fig. 111 shows in detail the construction of a universal joint as used by the National Motor Vehicle Company, Indianapolis, Ind. This joint is located immediately in rear of the transmission gear case, the main steel portion *A* being attached to the shaft of the transmission by the two keys *B*, indicated by dotted lines.

On the end of this portion is an annular bearing *C* held by the nuts *D*, with a lock-washer *E* between them. This bearing, and therefore the main portion of the universal joint, are prevented from pulling out of the case by the end adjuster ring *F* screwed into the main bearing sleeve *G*, and prevented from becoming unscrewed by the locking key *H*. The driving shaft *I*, turned to a ball

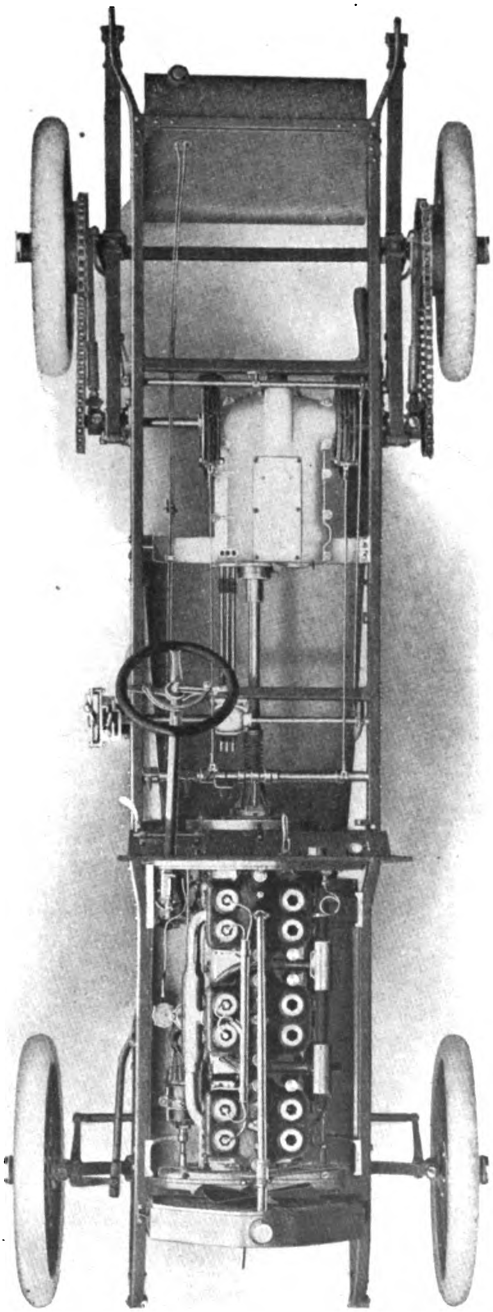


Fig. 108. Chassis of a Six Cylinder American Locomotive Car, Double-Chain Drive. American Locomotive Automobile Company, New York, N. Y.

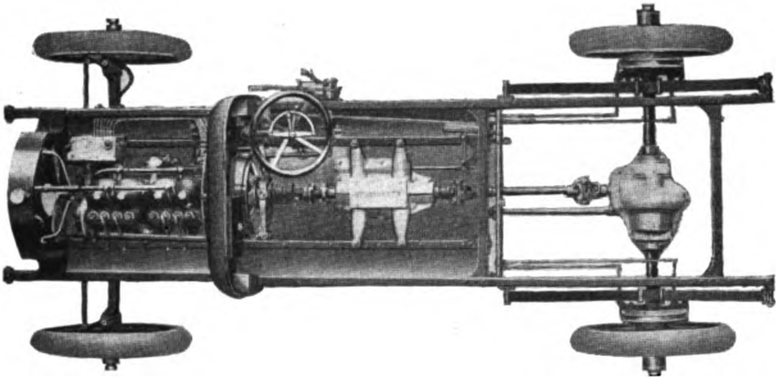


Fig. 109. Chassis of Studebaker Model L Car, Showing Direct or Shaft Drive, with Two Universal Joints.
Studebaker Bros. Mfg. Co., South Bend, Ind.

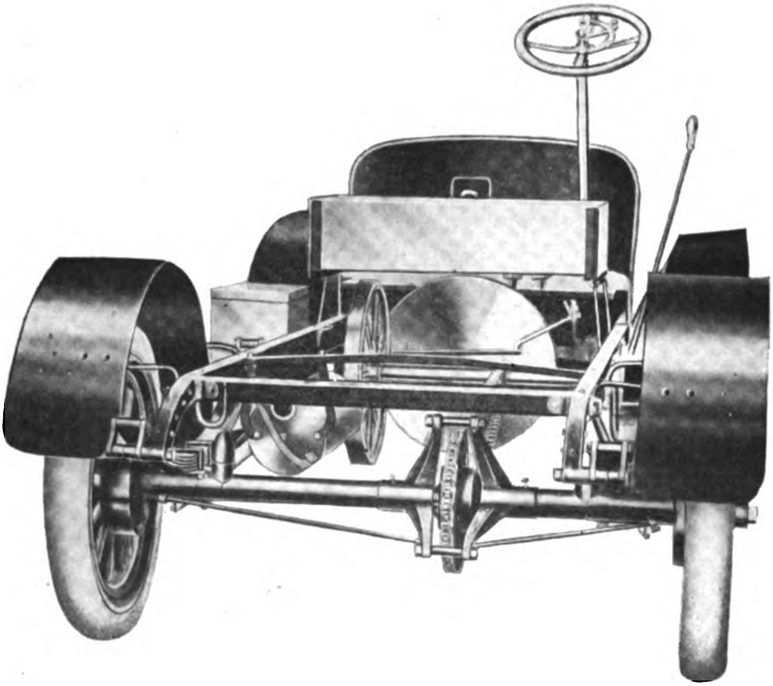


Fig. 110. Two-Disc Friction Transmission as Used in Cartercar.
Motor Car Company, Detroit, Mich.

shape at one end, has the hardened pin *J* running through it, upon which work two steel squares *K* sliding in slots in the main portion of the joint *A*, thus permitting a universal movement and also the sliding fore-and-aft movement of the driving-shaft, due to the action of the springs.

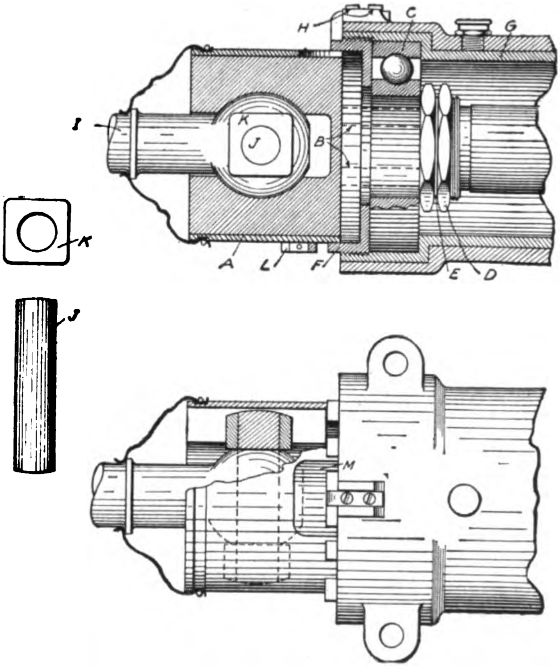


Fig. 111. Details of Universal Joint in National Car. National Motor Vehicle Company, Indianapolis, Ind.

There is a tubular sleeve which encloses the working parts of this joint, which is held in place by the cap screw *L*. An oval hole in the sleeve at *M* allows the removal of the squares, and permits the packing of the joint with grease, by turning it through an angle of 90 degrees. The end of the joint is covered by a cone-shaped piece of rawhide, fastened at one end to the sleeve and at the other end to the drive-shaft. A small hole through the center of the shaft allows some oil to flow into the joint from the transmission case.

Differentials or Balance Gears. When a car is turning a corner or passing over uneven places in the road, one rear wheel must turn faster than the other. It is necessary to provide mechanical means for this unevenness of turning, at the same time that uniform rotating power is furnished through the drive-shaft or driving sprocket.

Figs. 112 and 113 show how this is accomplished by means of the *differential* or *balance gear*. Fig. 112 is a view of the Studebaker Model F rear axle, showing housing removed and balance gear dis-

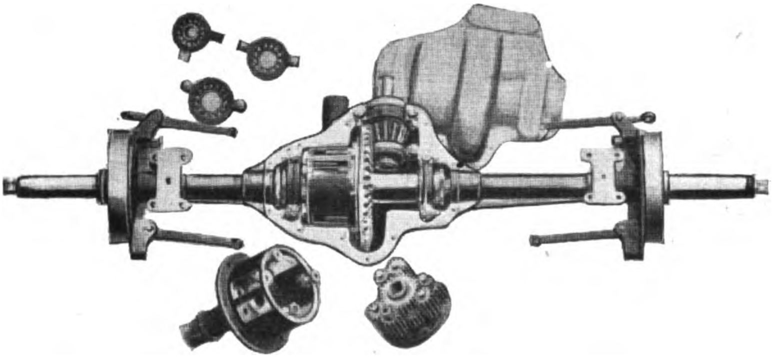


Fig. 112. Rear Axle Showing Differential or Balance Gear as Used in Studebaker Model F Car.
Studebaker Bros. Mfg. Co., South Bend, Ind.

sected. The small bevel pinion in the center of the cut is attached to the driving shaft. It meshes with the large bevel gear. On the inside of this bevel gear, is fastened a plate on which are mounted on short projecting shafts a number of small pinions, which mesh with gears fitting onto the square ends of the right and left rear axles, respectively. The amount of force transmitted is equal toward both

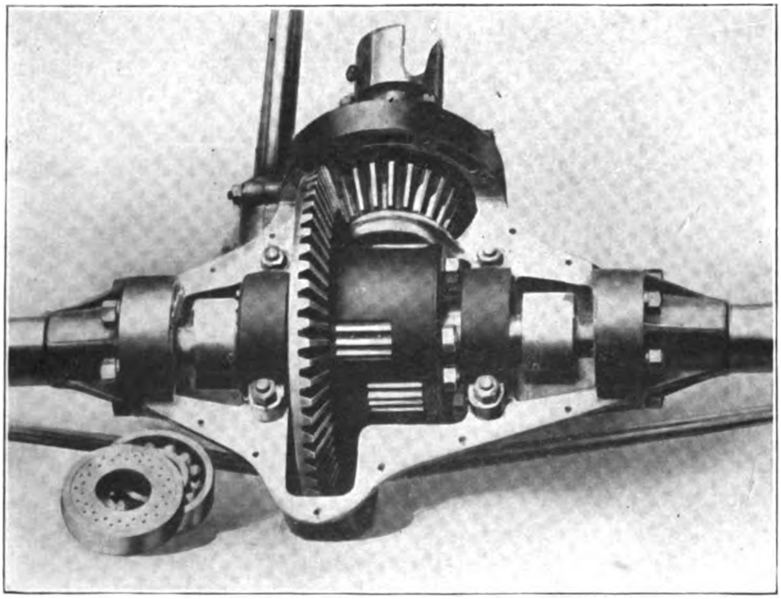


Fig. 113. Peerless Differential Gear.
Peerless Motor Car Company, Cleveland, Ohio

sides, and variations of speed between the two rear wheels are taken care of by rotation of the small pinions in opposite directions. Fig. 113 is a view of the Peerless differential. The principles of action are the same as in the one just described, the only difference being that small pinions carried on the large driven bevel gear are located directly in the center of the rear axle in line with the driving pinion.

Owing to the heavy strain on the large driven bevel gear, a number of makes provide a *thrust roller-bearing* against the back of the large bevel gear—that is, on the side opposite the teeth.

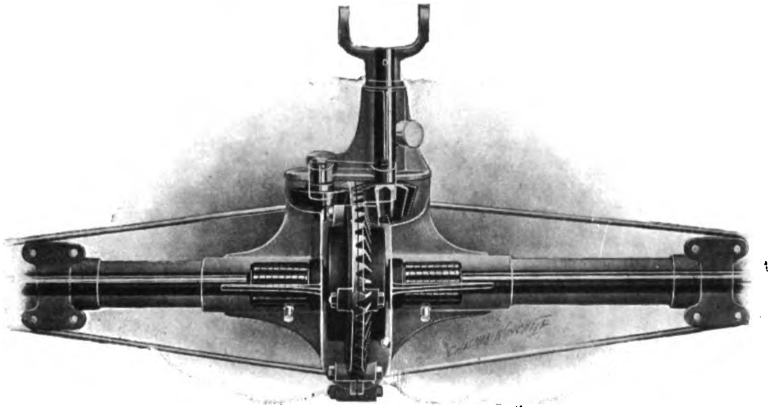


Fig. 114. Rear-Axle Construction on Maxwell Car, Showing Roller Thrust to Relieve Strain on Large Driven Bevel Gear of Differential
Maxwell-Briscoe Motor Company, Tarrytown, N. Y.

Fig. 114 is a view of the rear axle of the Maxwell car, showing this roller thrust.

LUBRICATION

Pipes for lubrication should not be too small. Sharp turns in oil pipe-lines should be avoided.

Oil and Oiling. The life and amount of service and satisfaction to be obtained from a motor depend very largely on the amount and quality of the oil used. The proper gas-engine cylinder oil should have a flash point of about 500 or 600 degrees Fahrenheit, and should contain only the minimum amount of carbon. It should always be filled at the temperature used. This necessitates using a different weight of oil in warm weather from that used in cold weather. For warm weather, use a heavy oil; and as the weather grows cooler, change to a lighter oil.

A teaspoonful of powdered graphite mixed with a little water inserted through the relief-pipe, will occasionally help greatly to reduce the amount of oil used.

The oil should be entirely drawn from the engine case about once a month, and all of the parts washed with kerosene. In refilling with oil, it should be deep enough so that when the connecting rods are down they will dip into the oil about ⅛ inch.

After cleaning, running the engine for a few revolutions with the case filled with kerosene will cut out any oil which may have become gummed on the cylinders or about the piston rings.

If the motor has not been run for some time, this should be done. If the motor is in constant service, it is not necessary, though it will do no harm.

For the transmission gears and differential gears, use a heavy oil corresponding to a steam-engine cylinder oil of cheap grade. Each of these gear cases should be about one-third full. For universal joints, use Albany grease. This is better than vaseline, as a slight heat transforms vaseline into liquid, and it runs out.

If springs squeak, force a small quantity of oil into the joints.

There is usually altogether too much lubricating oil applied to an engine. Six to eight drops a minute is ample for cylinder lubrication.

Chains, after having been thoroughly cleaned with kerosene, are dipped into melted tallow, and replaced after the tallow is cooled.

Forgetting to lubricate bearings is likely to cause firing of bearings, or *hot boxes*, which will necessitate stopping and delay.

The greatest drawback to the success of air-cooled motors, it has been claimed, is the problem of lubrication. The following method is adopted in the Marmon car to solve this problem:

> The crank-shaft is drilled with one-inch holes from end to end through the main bearings and through the four crank-pins. Three-eighths-inch holes are drilled through the arms of the cranks, connecting with the one-inch holes. It is claimed that this drilling does not weaken the shaft—in fact, that it strengthens it by removing internal strains on the forging. After the drilling is done, the outer ends of all the holes, except the one in the fore end of the shaft, are plugged, thus forming a continuous oil passageway from the forward

end entirely through the shaft into the rear main bearing. The crank-shaft is then drilled with radial holes at the center of every bearing, and these holes lead the oil from within the shaft directly into the bearing. A pump draws the oil through a screen from the bottom of the oil well, and forces it through a tube into the end of the crank-shaft, maintaining a uniform pressure constantly. It is claimed that oil smoke is never seen coming from the muffler of an engine with this type of lubrication.

Mechanically Operated Lubricators. Gravity and pressure systems of lubrication depend upon needle-valves, and the oil supply

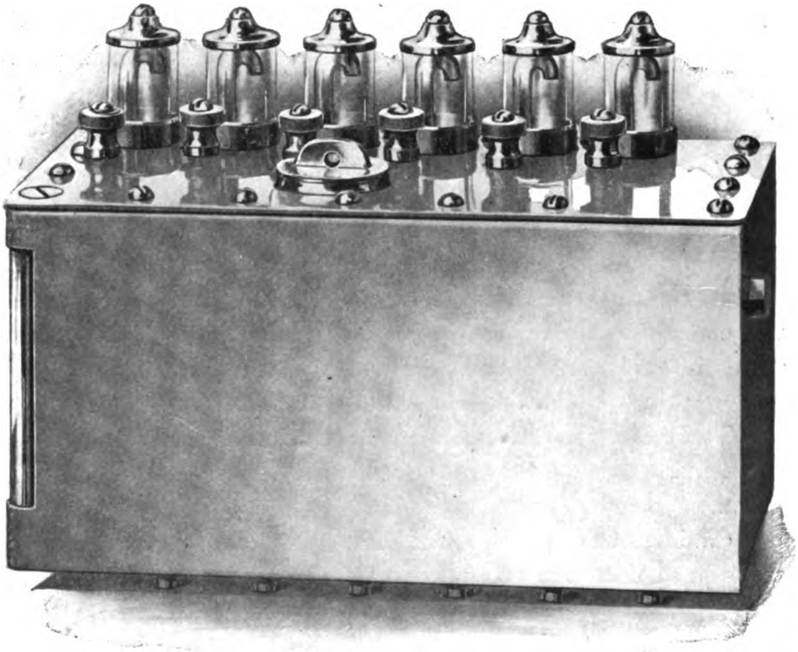


Fig. 115. External View of McCord Force-Feed Lubricator (Six Feeds); Polished Sheet-Brass Reservoir, Rotary Drive. McCord & Company, Chicago, Ill.

is the same for all speeds. Needle-valve regulation is difficult, because it is interfered with by the slightest particle of foreign matter in the oil and by temperature changes. An engine running at high speed requires more oil than at slow speed. Too much oil gums the bearings and cylinders, and increases friction; and with too little oil, they are liable to damage. Oil for automobile lubrication has to pass through a number of feet of small tubing before it reaches the points of lubrication, and requires in some cases to be delivered against pressure.

To provide for all of these problems, *mechanically operated lubricators* have been devised, which consist of pumps driven by some mechanism connected to the engine, so that when the engine starts the oiling begins at once, being so regulated that it varies in proportion with the engine speed and stops when the engine stops.

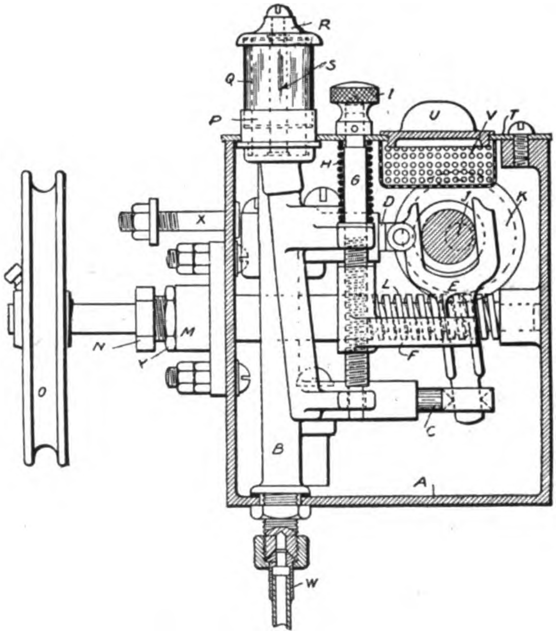


Fig. 116. Construction and Operation of Mechanically Operated Force-Feed Lubricator.
A—Reservoir: *B*—Pump; *C*—Pump Plunger, Suction; *D*—Pump Plunger, Delivery; *E*—Driving Yoke: *F*—Driving Yoke Fulcrum; *G*—Regulating Stem; *H*—Regulating Stem Spring; *I*—Regulating Button; *J*—Eccentric Shaft; *K*—Worm Gear; *L*—Worm; *M*—Stuffing Box; *N*—Stuffing Box Gland; *O*—Driving Wheel: *P*—Sight-Feed Glass Socket; *Q*—Sight-Feed Glass; *R*—Sight-Feed Glass Cap; *S*—Sight-Feed Nozzle; *T*—Cover; *U*—Strainer Plug: *V*—Strainer· *W*—Outlet Union Nipple; *X*—Studs; *Y*—Stuffing-Box Gland Lock-Nut.
McCord & Company, Chicago, Ill.

Figs. 115 and 116 are external and sectional internal views, respectively, of the McCord Force-Feed Lubricator. This lubricator consists of a rectangular reservoir and cover, provided with a filling opening closed by a plug, *U*, the oil, when poured into the reservoir, passing through a perforated sheet-metal strainer *V* which prevents any solid particles from getting into the tank. The force-feed mechanism consists of pumps *C* and *D*. The stroke of the pump *C* can be adjusted from the top of the lubricator without removing the cover. The second pump *D* has a constant stroke, and forces the oil after it has dropped through the sight-feed glasses *Q* onward to the point of lubrication. At the bottom of the sight-feed glasses, a gauze screen is placed as an additional protection to prevent even the

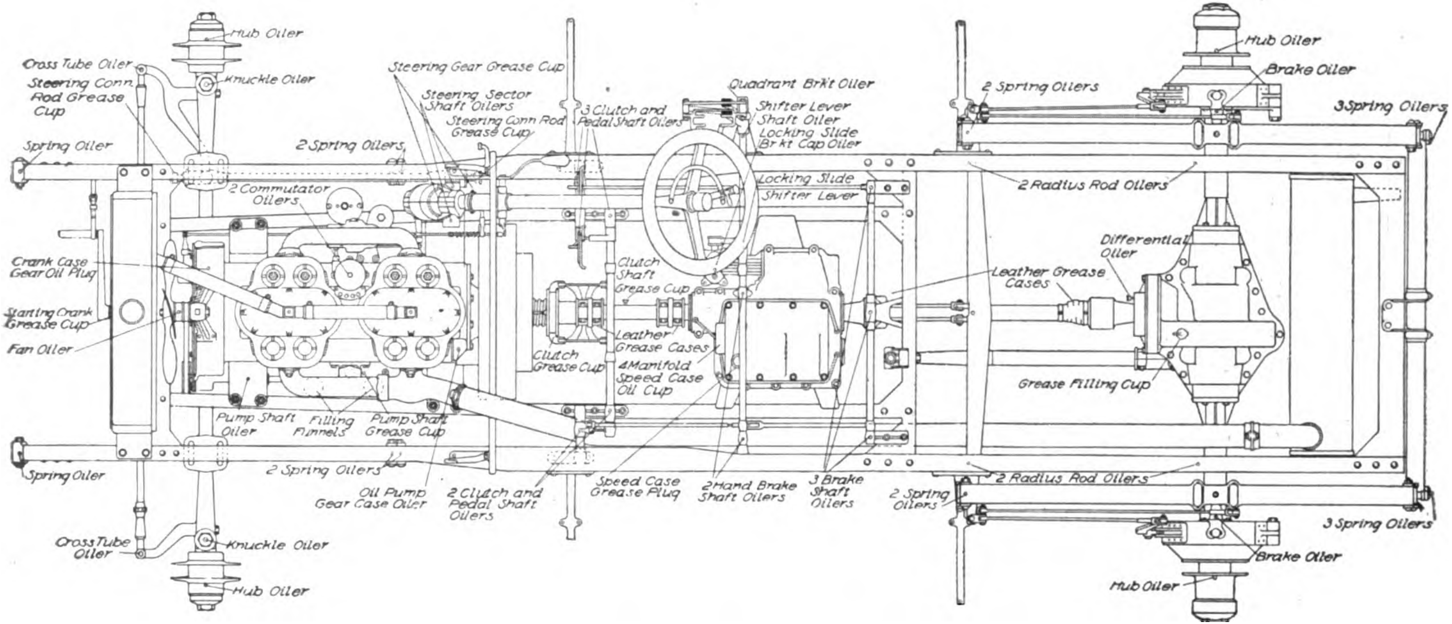
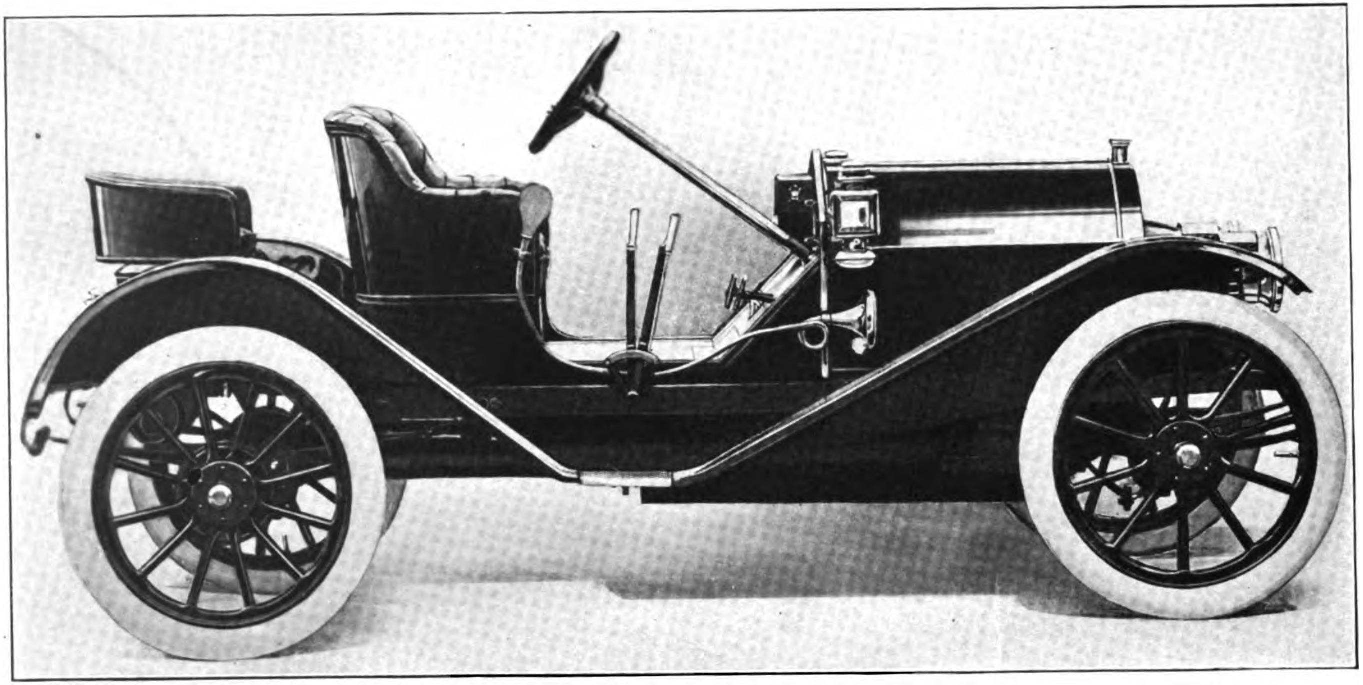


Fig. 117. Plan View of Peerless Car, Showing Principal Oiling Points. Peerless Motor Car Company, Cleveland, Ohio.



HUDSON TWENTY-HORSE-POWER ROADSTER
The Hudson Motor Car Co., Detroit, Mich.

smallest particle of foreign matter from being forced to the bearings. This is in full view of the operator, and can be removed and cleaned by taking off the brass cap. These sight-feed glasses are simply a protecting case for the oil drops, and contain no liquid adhering to the glass, which has always been a great disadvantage in the liquid sight-feed glasses. The amount of oil being pumped is at all times visible to the operator. The operation is as follows:

The pumps are driven by the eccentric *J* and adjustable lever *E*, by means of a worm gear *K* connected to the cam-shaft or other rotating part of the engine by the pulley or sprocket *O*. (In some lubricators this wheel is a thin ratchet wheel actuated by a pawl.) The stroke of supply-pump *C* is varied (thus increasing or diminishing the amount of oil pumped) by means of the sliding arm *F*, which forms a movable fulcrum for the pump-lever *E*. When the regulating stem *G* is screwed down, the fulcrum is raised and the stroke of the pump-piston is lengthened. Lowering the fulcrum decreases the stroke of the pump-piston and diminishes the amount of oil pumped. This pump delivers oil through the oil standpipe *S*, from which it drops to the delivery pump *D* attached to the jaws of the operating lever. The stroke of this pump is constant, and every drop of oil which falls into the pump chamber must be forced out through the delivery pipe *W* and on to the point of lubrication.

With the car running from fifteen to twenty miles an hour, each cylinder oiler should show ten drops per minute.

As a typical illustration of where lubrication should be applied, and how often, it will be well to study carefully Figs. 117 and 118, which show plan view and side elevation respectively of the Peerless car, with lubricating points plainly designated.

For this car the following lubricating instructions are given:

DAILY OIL AND GREASE

Eight grease cups should be given careful attention by the operator. These are located as follows: (1) On the right of the water pump, exhaust side of motor; (2) and (3) on the front end and rear end of the connecting rod which joins the steering column with the steering knuckles; (4) on the outside of the casing enclosing the worm and sector mechanism at base of steering column; (5) on the cranking device directly under the radiator well in front; (6) on the collar behind the spring on the clutch; (7) on fan-shaft; and (8) on driving-shaft between clutch and transmission. The above-mentioned grease cups should be filled with grease and screwed up a turn every day

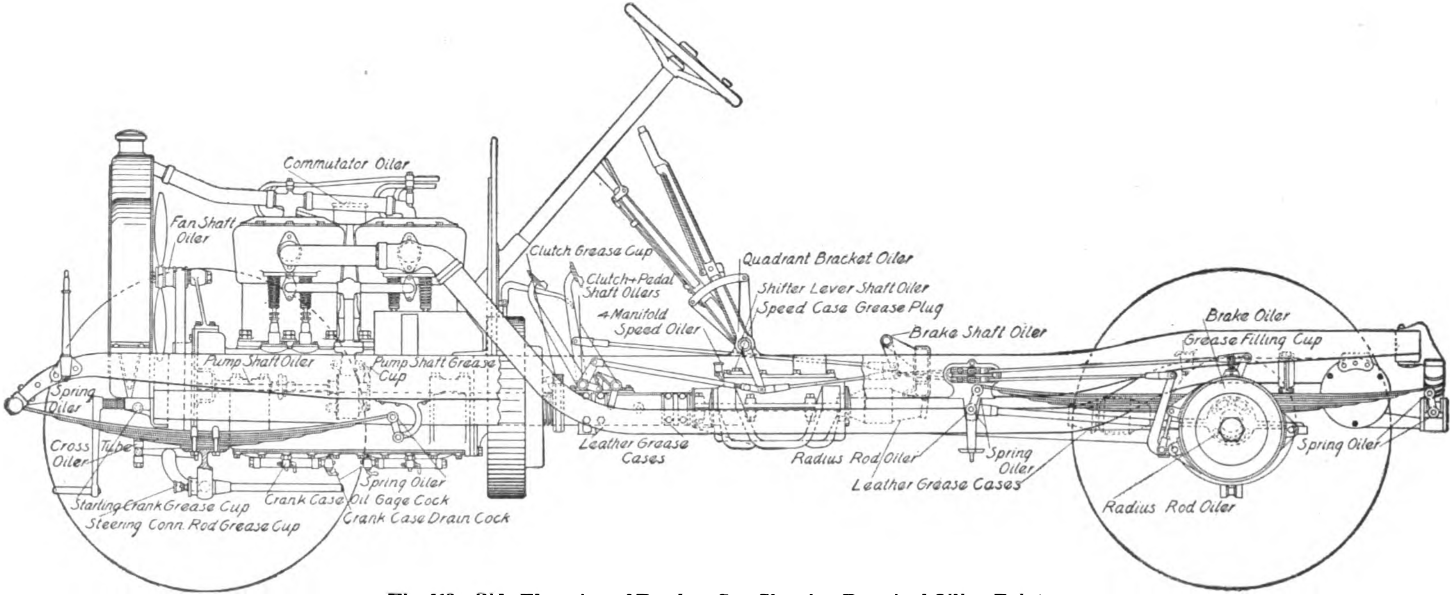


Fig. 118. Side Elevation of Peerless Car, Showing Principal Oiling Points.
Peerless Motor Car Company, Cleveland, Ohio.

before starting on a trip. When the caps have been screwed down as far as possible, unscrew, and fill again with grease.

Small oil-cups are located in the following positions:

Top of case covering half-time shaft to water-pump.
On brass cover operating drive to main oil-pump.
At end of all springs, to allow easy working of springs.
On the steering knuckles and at ends of cross-rod attached to steering knuckles.
On all rods pertaining to the brake and clutch mechanism.
On all knuckles pertaining to the brakes.

An oil-cup is located on top of the shaft in the commutator box. This should be given attention at frequent intervals, to have the bearings well lubricated. Half-way down the vertical casing carrying the commutator shaft, is another small oil-hole. This shaft should be oiled occasionally.

The slots through which the brake-equalizers work should have some oil occasionally.

The entire lubricating system should be thoroughly gone over every month, to insure perfect running of the car. Too much oil is better than too little, and it is advisable that the operator give this his most careful attention.

Oil in Crank-Case. The correct level of the oil in the crank-case is regulated by standpipes connected with pet-cocks underneath the crank-case. Before starting on a run, it is important to know that the crank-case is properly filled. Open both crank-case oil gauge-cocks; and if the oil runs out, allow it to run until the excess is all withdrawn. If the oil does not run out of the pet-cocks, fill the crank-case through the vent-pipes until the oil commences to drain off through the pet-cocks. Care should be taken not to open the crank-case drain-cocks.

Transmission. The transmission case should be filled with about five pounds of grease to which is added about a quart of light paraffine oil. This lubricates the shafts, yokes, levers, and in fact all wearing parts. The four bearings are lubricated by a manifold oiler located at the front of the transmission case. This manifold should be filled before starting on a trip. An oil-hole in the cover of the transmission case allows opportunity to refill the transmission with grease and oil at any time it is deemed necessary. This should be at least once a month.

At the end of three months the top of the transmission case should be removed, and the case flushed with kerosene and refilled with grease and oil. This may be done by drawing off the oil through the drain-plug at the bottom of the transmission case.

Universal Joints. The universal joints between the clutch and transmission and between the transmission and the rear axle are packed in grease, and housed in leather cases held securely in place by a brass band easily removable for replenishing with grease. This should be done about once in two months.

Wheels. The wheels should be taken off, cleaned, and packed with grease about once in two months or oftener, depending on usage. The oilers on top of the rear and front hubs should be filled daily.

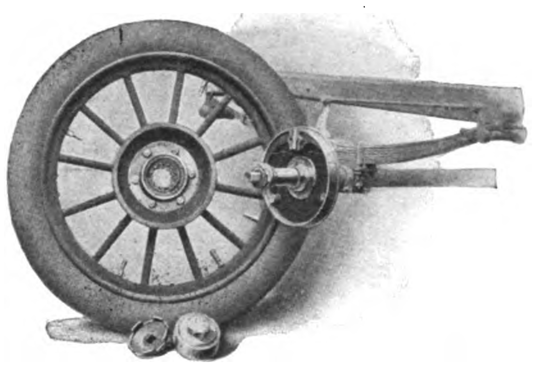


Fig. 119. Rear Wheel of Studebaker Model G Car, Showing Hub Drum and Brake.
Studebaker Bros. Mfg. Co., South Bend, Ind.

Differential. Under ordinary conditions the bevel and differential gears should be cleaned once in three months. The cover of these gears should be taken off, and all the old grease removed and the gears carefully packed with new grease, care being taken to see that the grease is well worked in. The differential case holds about seven pounds of grease. By means of a plug in the differential case, it should be replenished with grease and oil at least once a month.

BRAKES

Most cars are provided with two brakes—one known as the *ordinary brake*, and the other as the *emergency brake*. It is most convenient for the operator to have the ordinary brake operated by a foot-pedal, and the emergency brake by means of a lever.

Formerly one of the brakes was applied to the clutch or drive-shaft. This method has been found to throw an undue strain on these parts, and the best modern practice is in favor of *internal* and *external brake-bands* acting on hub drums on the rear wheels, one of these serving as the ordinary brake, and the other as the emergency.

Fig. 119 shows the rear wheel of the Studebaker Model G car, showing location of hub drum and brake.

Fig. 120 shows the internal and external brake system of the Peerless car. In this car the brakes act on a drum on each wheel, being operated through equalizers which give an even pressure on each wearing surface. The foot-brakes are made of steel bands, fiber-lined, and operate on the drums externally. When not engaged, the external bands are kept from the drum by means of springs at top and rear.

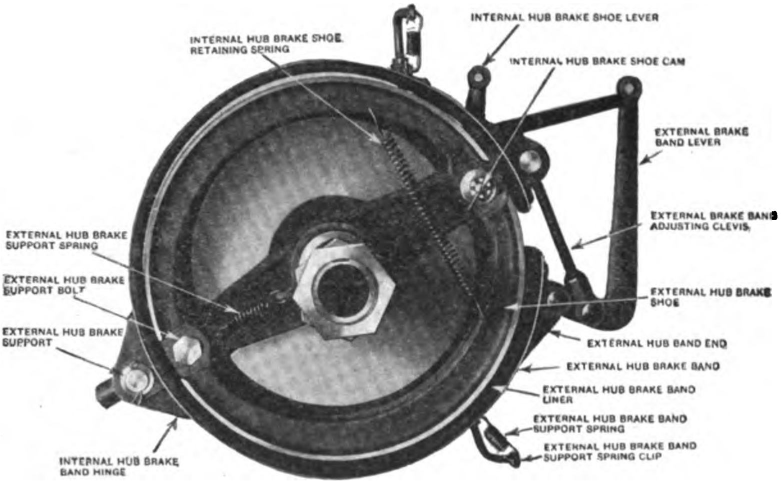

INTERNAL HUB BRAKE SHOE LEVER
INTERNAL HUB BRAKE SHOE RETAINING SPRING
INTERNAL HUB BRAKE SHOE CAM
EXTERNAL BRAKE BAND LEVER
EXTERNAL BRAKE BAND ADJUSTING CLEVIS
EXTERNAL HUB BRAKE SUPPORT SPRING
EXTERNAL HUB BRAKE SUPPORT BOLT
EXTERNAL HUB BRAKE SHOE
EXTERNAL HUB BRAKE SUPPORT
EXTERNAL HUB BAND END
EXTERNAL HUB BRAKE BAND
EXTERNAL HUB BRAKE BAND LINER
EXTERNAL HUB BRAKE BAND SUPPORT SPRING
INTERNAL HUB BRAKE BAND HINGE
EXTERNAL HUB BRAKE BAND SUPPORT SPRING CLIP

Fig. 120. Internal and External Brake System of Peerless Car, Showing Details Connected with Operation.
Peerless Motor Car Company. Cleveland, Ohio.

The emergency hand-brake operated by the outside lever on the right-hand side of the car, engages the drums internally. These brakes are bronze bands expanded by a wedged cam-lever. These brakes are held away from the drum by means of springs, as shown in the figure.

After a time it may be found necessary to adjust these brakes to take up for wear. This may be done by screwing up the brake-rod clevises to the rear of the equalizers, until the proper adjustment is reached. Care should be taken not to screw up these clevises so far that the band will *drag* on the drum. By jacking up the axle so that the wheels clear the floor, and spinning the wheels around by hand with the brakes in released position, it may be readily noticed if there is any dragging action.

Fig. 121 shows a brake drum of the Premier car, with details of the internal expanding and external contracting brakes.

BEARINGS

Bearings are either *plain cylindrical, cylindrical in halves, roller bearings, ball bearings,* or *annular.*

Plain cylindrical bearings are usually bronze sleeves, and are used at points where no adjustment is expected to be necessary.

Cylindrical bronze bearings cast in halves, the halves being separated by shims of soft metal or leather liners, are used in various parts of different makes of cars, a good many cars using this type in the main or crank-shaft bearings of the engine. In this type a moderate amount of wear may be taken up by tightening the cap screws which fasten the halves of the journal-boxes together. A greater amount of wear may be taken up by removing the liners or shims, and replacing with others somewhat thinner.

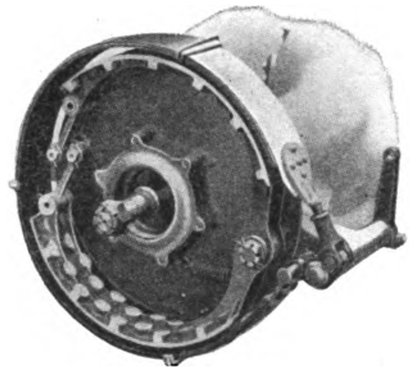


Fig. 121. Brake Drum.
Showing detail of internal expanding and external contracting brakes.
Premier Motor Mfg. Co., Indianapolis, Ind.

Fig. 122 shows the American Ball Bearing Company's front hub. The nut *A*, which adjusts the cone *D* on the right-hand axle, is provided with a right-hand thread, and the set screw *B* has a left-hand thread. The dust cap *C* has a left-hand thread. All of these parts on the left-hand axle are reversely threaded. To remove front wheels, unscrew brass cap *C*; and by means of a hexagon wrench, unscrew adjusting nut *A*, but do not alter the position of set screw *B*. When replacing wheels, be sure that the ground angular surface on cone *D* is in contact with the balls. The nut *A* should be set firmly.

To adjust front wheel bearings, proceed as above; withdraw the set screw *B*; screw on the adjusting nut *A* until the adjustment is right.

Now turn off the nut *A* about one half-revolution and tighten the set screw *B*. If there is lost motion in the bearing, loosen nut *A*, back out screw *B* a little, and tighten nut *A* again. A bearing is properly adjusted only when screw *B* makes it impossible to force nut *A* on any further, and all lost motion is out of the bearing, but without being tight. Remember that one can easily put tons of useless and harmful pressure on the bearings with careless use of the wrench.

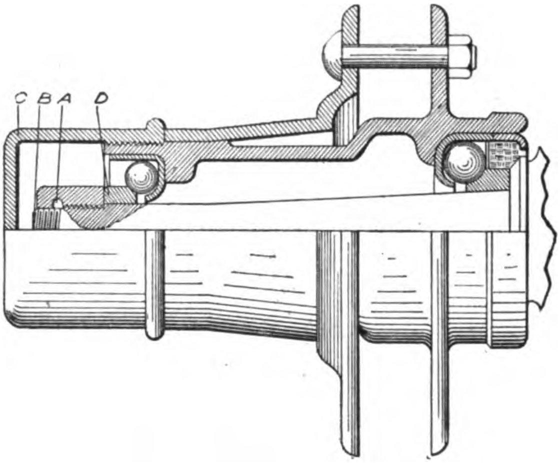


Fig. 122. Ball-Bearing Front Hub.
American Ball Company, Providence, R. I.

Fig. 123 shows the Timken roller bearing as applied to the Franklin car. The part of the cut at right shows a correct adjustment, and the part at left, a faulty adjustment of this bearing. To be correct, the axle lock-nut *A* must be locked tight against the shoulder *B* on the spindle. When the nut is against this shoulder, the wheel must revolve freely without side play. In making the adjustment, if the wheel becomes tight before the nut shoulders, the

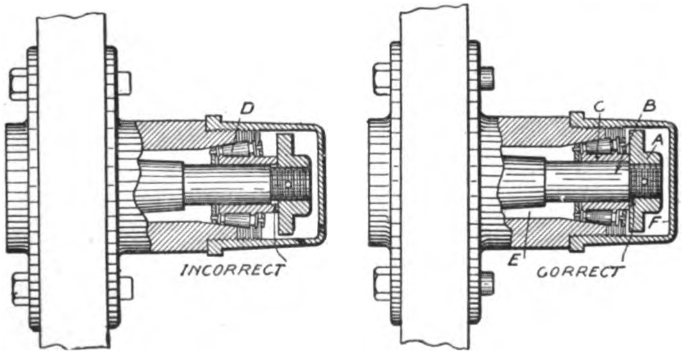


Fig. 123. Timken Roller Bearing as Used in Franklin Car.

cone *C* is too long, and must be ground off on its face. If, after the nut *A* is screwed up tight against the shoulder, there is side play in the wheel, the cone *C* is too short; and the correct length must be made up by placing one or more thin metal washers between *C* and *A*, until the bearing has no side play, and the nut *A* is tight against the shoulder *B*.

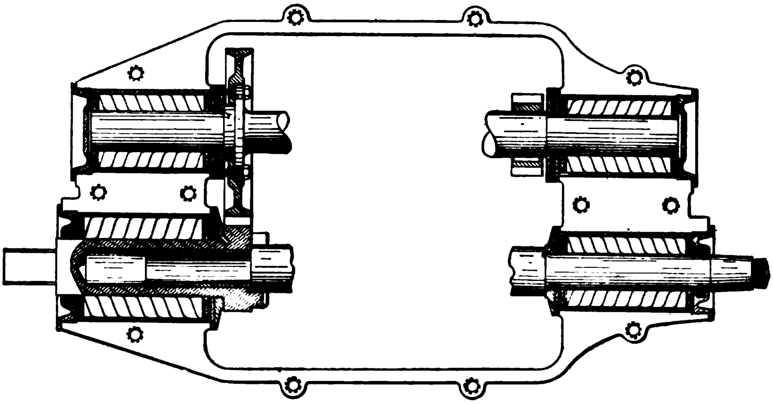


Fig. 124. Hyatt Roller Bearing as Used in Transmission Case. Hyatt Roller Bearing Company, Harrison, N. J.

A bearing incorrectly adjusted, as shown in the left part of the cut, will act as follows: As the wheel revolves forward, friction is exerted by the cone *C* upon the nut *A*, causing it to screw in toward the shoulder. This forces the cone *C* up on the spindle, and jams the rollers *D* so that they will break and thus destroy the bearing.

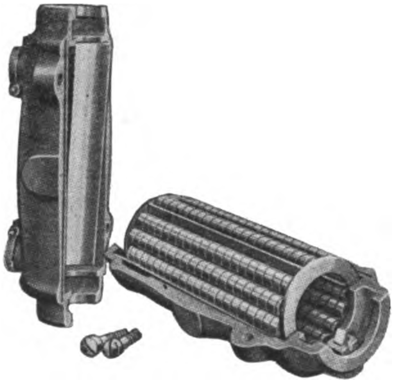


Fig. 125. Hyatt Standard Bushing Hyatt Roller Bearing Company, Harrison, N. J.

Fig. 124 shows the Hyatt roller bearing as applied to a transmission gear case; and Fig. 125 shows a Hyatt standard shaft-box. Bearings of this type are very generally used in transmission cases and also in rear axles. They have the advantage of not requiring as much attention as plain bearings, in the way of lubrication; also the advantage of flexibility, enabling them at all times to present a bearing along the entire length, resulting in a uniform distribution of load. Fig. 126 shows an annular ball bearing; and Fig. 127 shows how annular ball bearings are used on the crank-shaft in the Corbin car. The annular type of ball bearing is displacing the plain ball bearing, as the caging of the balls results in a minimizing of wear, making them bearings that do not require any adjustment.

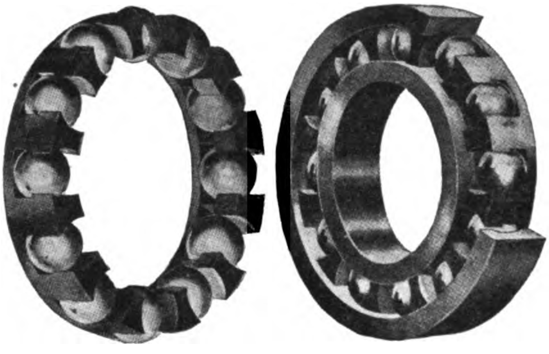


Fig. 126. Annular Ball Bearing.
Silent Type with Cage Spacer.
Standard Roller Bearing Company, Philadelphia, Pa.

WHAT TO DO TO A NEW CAR

The first thing to do is to see that oil is provided at all parts where one piece moves on another. Next remove the plug or screw top of water tank, insert a funnel, and fill with clean water. In freezing weather, some anti-freezing solution must be used. There are various such solutions on the market, some of them consisting of oils, and others mostly glycerine. In case there is a standpipe in the water line, with a cock at the top, open this cock to permit the entrained air to escape, being sure to close this cock again after the tank has been filled.

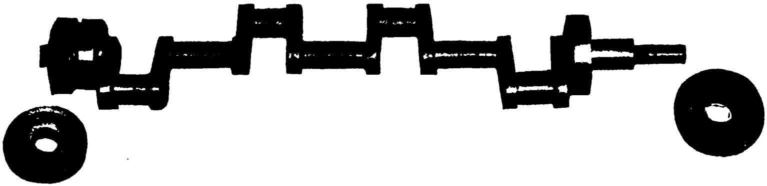


Fig. 127. Annular Ball Bearings Applied to Crank-Shaft.
Corbin Motor Vehicle Corporation, New Britain, Conn.

In case of an air-cooled engine, the above instructions in regard to water are of course unnecessary.

Next remove plug or screw-top from gasoline tank, insert a separate funnel, and fill with clean, fresh gasoline, straining it through a screen or preferably a chamois skin in the funnel; then replace the gasoline and water-plugs or screw-tops, seeing that they are firmly but not too tightly fastened.

See that the cock in the gasoline line leading from tank to carbureter is opened, and try whether gasoline flows freely to carbureter, by pressing down the primer until gasoline flows from the carbureter. If a motor has been stopped only a short time, it will not be necessary to make use of the primer. In fact it is undesirable to use the primer when the engine is still warm, as it is likely to give too rich a mixture, and such a mixture will not explode.

See that all oil-cups are full, and that they are adjusted to feed approximately 15 drops per minute.

See that the transmission is provided with a good supply of heavy oil. This will require attention about once a week. In cold weather a lighter oil will be required here than in warm weather.

TO START THE ENGINE

First, disengage the clutches.

Second, put on the brakes.

Third, open the throttle slightly.

Fourth, turn the switch handle to the "On" position.

Fifth, push the spark-lever away back to its point of greatest retardation or lateness.

Sixth, when the engine is cool, it may sometimes be necessary to prime the carbureter slightly by lifting the carbureter float-needle. This is provided for in different ways in different cars and different carbureters. In some cases a rod is made to extend from the carbureter to some convenient point, such as the floor or dash or side of the car, this rod being so arranged that by pushing it the float-valve of the carbureter is opened. Do not prime too much, as you are likely to get too much gasoline at the start; and the only remedy for this is the tiresome process of repeatedly cranking until all of the too rich mixture has been pumped through your engine.

Seventh, turn the crank clockwise, pulling upwards with a quick, sharp pull. *Never push downward.* The reason for this is that if the spark is accidentally advanced, the charge may explode before dead center, and kick backwards, resulting in the straining or breaking of the operator's arm.

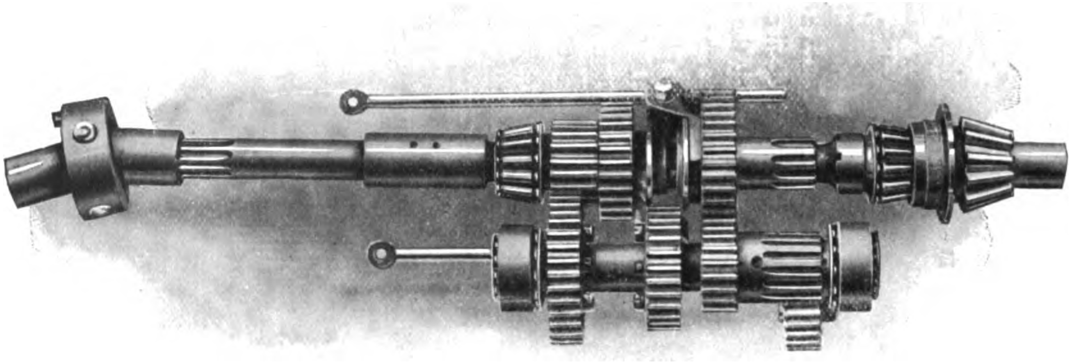
Make sure that spark lever is away back, that switch is turned on, and that you can hear the vibrator buzz every time the engine goes over compression. A weak battery will cause faint buzzing.

Failure to Start. Should the engine not start at a few turns of the crank, it is of no use to work one's self tired keeping on cranking. It is best to see whether the batteries have been switched on, whether the gasoline is turned on, and if the ignition is at the right point. It may be that the carbureter is flooded, delivering too rich a mixture. In this case, considerable cranking will be necessary in order to empty the engine of the excess of gasoline, the supply being shut off during this cranking.

Other possible causes of failure to start are a sooty spark-plug or dirty commutator. Note whether the spark-coil on the dash buzzes during the cranking. If so, it indicates that the ignition coil and connections are not at fault. More likely the reason will be that the spark-plugs are dirty or sooty. Remove the plugs, and insert new ones, which should always be kept on hand. The plugs removed can readily be cleaned and used in their turn for replacement, if the plugs in use become fouled. Excessive cold, or water in the gasoline, or faulty compression, are possible causes.

The carbureter may be empty There may be dirt in the pipes or carbureter. Gasoline in the carbureter may be stale. Drain and clean the carbureter, and give it a charge of fresh gasoline. The valves may be gummy and need cleaning. For instructions regarding carbureters, see pages 55 and 61.

The springs of the inlet valves may be too strong and may need loosening. For instructions in regard to valves, see page 56.



THE SLIDING-GEAR TRANSMISSION ON THE GLIDE CAR
The Bartholomew Co., Peoria, Ill.

AUTOMOBILE MECHANISMS

PART I

VALVE GEARS

Probably the most important thing about a four-cycle, gasoline engine is the valve, or more correctly, are the valves, for the usual number is two per cylinder. The opening and closing of these control the functions of the engine, for if the valve does not open and allow a charge of gas to enter, how can the piston compress and the ignition system fire a charge? Similarly, if the exhaust valve is not opened and the burned gases allowed to escape, they will mingle with and dilute the fresh, incoming charge, possibly to the extent of making the latter into a non-combustible gas. This is purposely stated in this way because both methods mentioned have been utilized for governing the engine speed, although not to any great extent in automobile work.

Cams. Granting, then, the necessity for proper means to regulate the inflow and outgo of the charge and consequent products of combustion, as exemplified by the valves, the next most important part is the one which controls the movement of the valve, and is, therefore, essential to the success of the latter. This is what is known as a *cam* and in the usual case amounts to an extension of or projection from the so-called *cam shaft.* Inasmuch as the valve functions only come into play upon every other stroke of the crank shaft, this cam shaft is gear-driven from the crank shaft, so as to rotate at half the speed of the latter. This is very simply effected by having the cam gear twice as large as the crank-shaft gear, that is, with twice as many teeth. As the same valve is never used for both the inlet and the exhaust, so the cams are seldom made to do more than the one thing, namely, operate one of the valves. From this has grown the custom of referring to them according to the function of the valve which they operate—*inlet cam, exhaust cam,* etc.

In laying out or designing a set of cams for a gasoline engine,

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TABLE I
Timing Regulation of a Number of Prominent French Motors

Nos.		Lead of Exhaust Opening	Lag of Inlet Closing	Ignit. Advance	Lag of Exh. Closing	Lag of Inlet Opening	Relation of Conn. Rod to Radius Crank	R.p.m. at Full Power
1	Ours	55°	20°	var.	0°	15°	4.76	1 000
2	Charron.—20/30 h.p., 1908	44°	0°	—	0°	1°	4.55	1 100
3	Rossel.—40 h.p., 4 cylinders	38°	23°	—	0°	2°	4.29	1 100
4	Gregoire.—10/14 h.p., 4 cylinders, 1908	53°	0°	—	0°	5°	4.18	1 200
5	Motobloc.—24 h.p., 100/120 1908	45°	10°	—	5°	10°	4.75	1 200
6	Panhard-Levassor	45°	40°	—	0°	0°	4.5	1 200
7	Hotchkiss.—4 cylin. 95/100	44°	33°	—	10°	17°	4.27	1 300
8	Cottin-Desgouttes.—18/22 h.p	46°	30°	38°	8°	15°	4.15	1 300
9	Brouhot.—12 h.p., 4 cylinders, 75/110	45°	45°	30°	0°	20°	5	1 300
10	Cornilleau-Ste-Beuve.—20/30 h.p., 1908	56°	20°	43°	6°	20°	4.62	1 300
11	Mutel.—40 h.p., 1908	62°	21°	var.	28°	26°	4.4	1 300
12	Berliet.—22 h.p., 1908	48°	38°	—	9°	17°	4.5	1 300
13	Peugeot (*Paris*).—18/24 h.p. 1908	58°	18°	38°	0°	10°	4.76	1 300
14	Labor.—20/30 h.p.	51°20′	0°	var.	0°	0°	4.18	...
15	Luc Court	45°	0°	—	15°	30°	4.25	...
16	Brasier	45°	25°	34°	0°	7°	4.5	1 350
17	Peugeot (*Beaulieu*)	51°30′	58°	31°	20°	15°	4.78	1 400
18	Aster.—9 h.p., 105/120	40°	40°	var.	0°	0°	4.3	1 400
19	Rochet-Schneider.—24 h.p., 100/120	40°	20°	20°	0°	20°	4.75	1 400
20	De Dion-Bouton.—12 h.p., 4 cylinders, 1908	45°	45°	30°	0°	0°	4.7	1 400
21	Eudelin	36°	20°	var.	4°	8°	4.3	1 450
22	Farcot.—14 h.p., 80/100	36°	10°	—	2°	6°	4	1 500
23	Chenard-Walcker	36°	36°	—	0°	0°	5.25	1 500
24	Darracq.—10/12h.p., 100/120	48°	30°	21°	0°	0°	4.5	1 500
25	Aries.—14/18 h.p.	58°	44°	20°	13°	18°	4.91	1 500
26	Vinot-Deguingand.—12/16 h p., 80/110	30°	15°	27°	0°	15°	4.54	1 500
27	Sultan.—9/12 h.p., 4 cylinders, 75/110	58°	42°	32°	14°	22°	4.55	1 600
28	Renault.—8 h.p., 2 cylinders	32°	26°	33°30′	10°	23°30′	4.33	1 600
29	Unic.—20 h.p., 75/110	53°	40°	30°	10°	34°	4.5	1 650
30	Sizaire et Naudin.—15 h.p., 120/110	44°	37°	var.	0°	15°	5.25	1 700
31	Larrad Device	52°	17°	—	22°	17°	....	.....
	Average	46°20′	26°15′	—	5°40′	8°6′	....	.....

The motors are arranged in this table in the order of their increasing speeds. The angles are figured in degrees, counting from the nearest dead center. "Var." means that the point of ignition may be advanced or retarded by the driver.

such as is used on an automobile, it is first necessary to decide upon the exact cycle upon which to operate the engine. By this is meant the exact length of time, as referred to the stroke, in which the valve action will take place. Upon this subject, designers all over the world differ, and no wonder, as this cycle can but be judged by results, for it is impossible to watch it as it transpires. Deductions differ, therefore, as to what happens, and consequently, as to the effect of various angles of beginning and ending of the valve actions.

Tables of Valve Settings. Some time ago a table of the valve settings used by the foremost French car designers, was compiled and is here given, Table I, as a basis of comparison with the valve data of American types, Table II. In studying these tables, it should be borne in mind that all angles are spoken of in terms of the crank shaft, and are usually referred to the two dead centers, commonly spoken of as the *upper dead center* and the *lower dead center*.

Now, if the average of the numerous examples of good practice be taken, it is not a hard matter to explain the form of the cam and its derivation. The height of the upper surface of the highest part of the cam above the surface upon which the valve actuating device normally rests, determines the *lift* of the valve, which is the name given to the amount it is opened or lifted. This is not really the lift of the valve because of the fact that in all valve operating systems there is a certain amount of clearance between the lower end of the valve stem and the upper end of the valve lifter mechanism. This

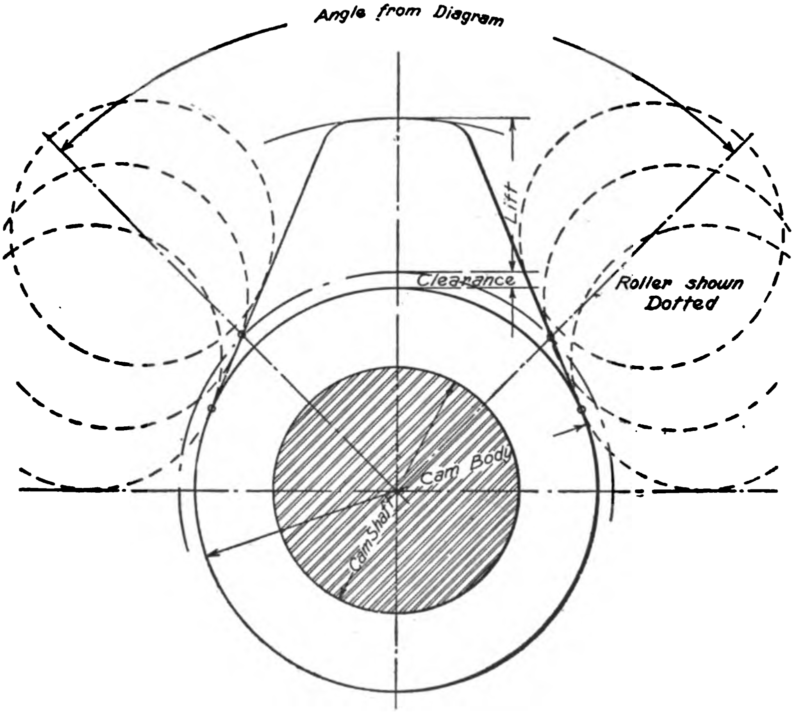


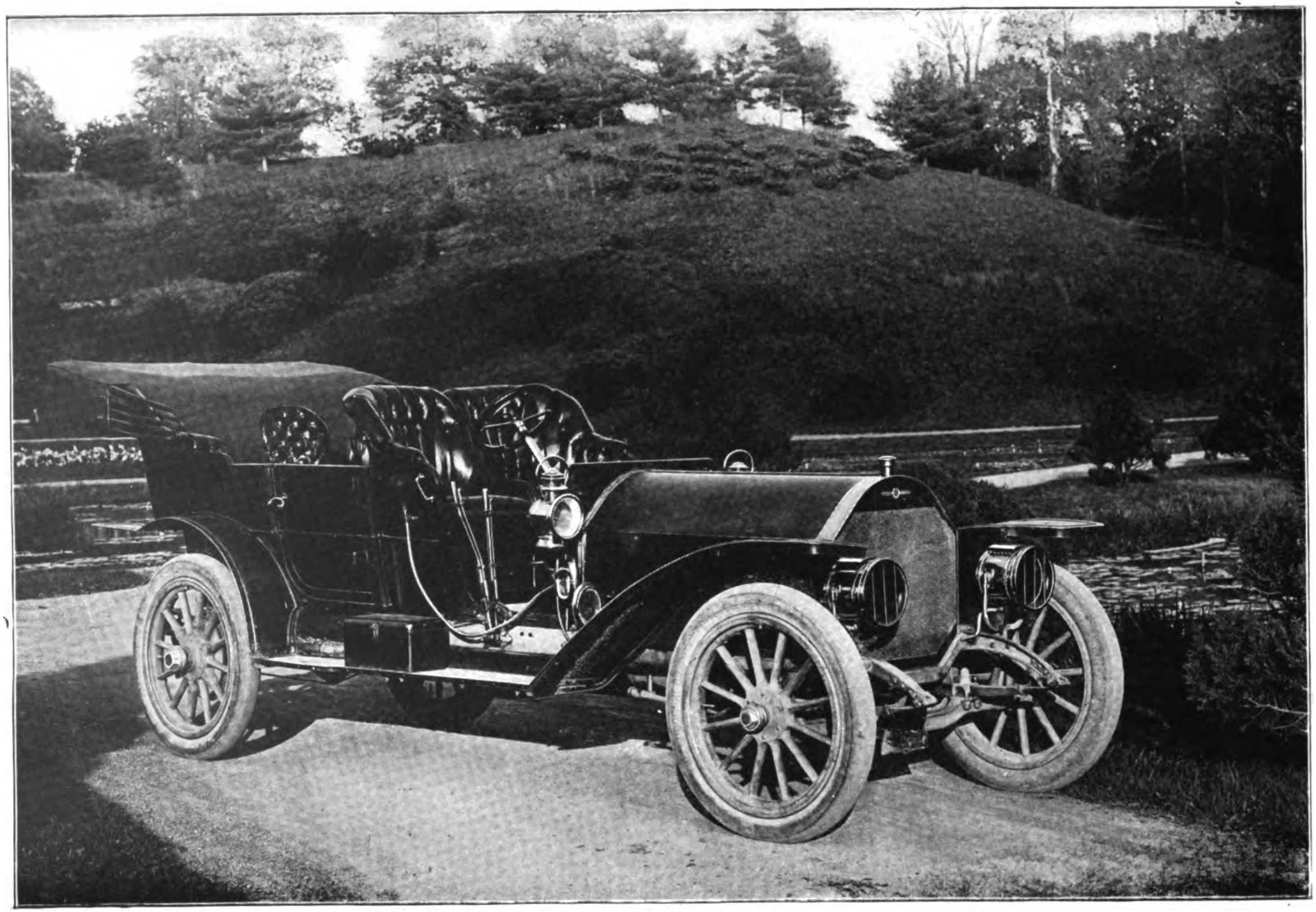
Fig. 1. Method of Laying Out Cams.

TABLE II

Timing Angles for Maxwell Motors and Other Data of Interest

Model	Timing of Valve in Degrees and Equivalents of Inches on Flywheel								Diam. of Fly-wheel	Stroke of Cyl-inder	Diam. of Cyl-inder	No. and Type of Cyl-inders	H.P. of One Cylin-der	Normal Speed Rev. per Min.	Max. Speed Rev. per Min.
	Inlet				Exhaust										
	Opens		Closes		Opens		Closes								
	Degrees	Equiv.	Degrees	Equiv.	Degrees	Equiv.	Degrees	Equiv.							
L..........	15° late	2⅜″	40° late	6¼″	40° early	6¼″	10° late	$1\frac{9}{16}$″	18″	4″	4.5″	2 horiz.	6	800	1200
H..........	15° late	2⅝″	40° late	7″	40° early	7″	10° late	1¾″	20″	5″	5″	2 horiz.	8	750	1000
Q..........	15° late	2.289″	40° late	6.104″	40° early	6.104″	10° late	1.526″	17½″	4″	3.75″	4 vert.	4.5	900	1400
K..........	15° late	2.487″	40° late	6.633″	40° early	6.633″	10° late	1.691″	19″	4½″	4.25″	4 vert.	6.5	800	1200
M..........	15° late	2⅝″	40° late	7″	40° early	7″	10° late	1¾″	20″	5″	5″	4 vert.	10	800	1200

NOTE—In timing valves, piston should be on upper dead center.



"BIG SIX" TOURING CAR
Stevens-Duryea Company, Chicopee Falls, Mass.

clearance must be taken up by the cam before the valve itself is actually lifted, so, to obtain the true lift, the amount of the clearance is subtracted from the lift as determined by the cam height. Knowing this, designers usually predetermine the clearance and allow for it in the height of the cams.

Cam Design. In order to lay out a set of cams, not only must the cycle be fixed, but the clearance as well. Fig. 1 shows the way to go about this; the size of the shaft is simply determined, and if other means fail, the empirical formula may be used:

$$\text{Cam shaft diameter} = .625\,D - \tfrac{1}{8}''$$

in which D is the clear diameter of the valve opening in inches.

Having the cam-shaft diameter fixed, lay it out and about it circumscribe the cam thickness. This may be from one-eighth of an inch, upon very small, light-weight engines, to three-eighths inch on larger and heavier motors. Around this, in turn, describe another circle, distant from the cam surface a distance equal to the clearance. A fourth circle representing the height is shown only partly complete.

From the cycle previously determined upon, the total angle of inlet valve opening, for instance, is found by simple addition and subtraction; thus, if the inlet is to open 10 degrees past the upper center and close 20 degrees past the lower center, this makes the valve remain open a total of 190 degrees upon the crank shaft. As the cam shaft turns but half as fast, and therefore but half as far in the same length of time, for the cam this angle will be halved, or 85 degrees. Proceed to lay out half of this, or 42½ degrees, on each side of the vertical center line. A line forming this angle with the center line will intersect the line representing the clearance in a point. Through this point draw a line which will be tangent to the circle representing the surface of the cam, and prolong it upwards to meet the upper circle. Drawing in a round corner completes the cam lay-out. By sketching in the cam roller the progression is shown. Fig. 2 illustrates the complete valve motion. This is an example taken from actual practice, being the valve action as used on the Pierce-Arrow engines, made by the Pierce-Arrow Motor Car Company, Buffalo, N. Y. In the figure, *A* is the cam fixed on the cam shaft. As the latter rotates, and the higher part of the cam comes uppermost, the push rod *B*, the roller *C* of which bears on the face of the cam, is constrained to rise. The rising is opposed by the valve spring *F*, which is compressed by the rising between the two collars,

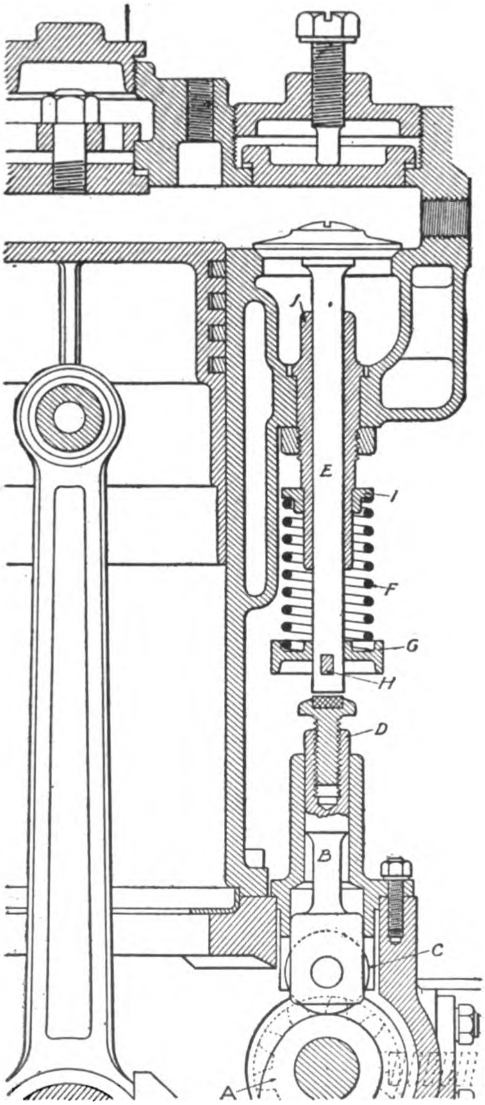


Fig. 2. Complete Valve Motion—Cam Shown at *A*.
Pierce Arrow Motor Company, Buffalo, N. Y.

one, *G*, being held in the valve stem *E* by the key or pin shown in section at *H*. The other, *I*, is fixed in the valve rod guide *J*, whose function is to guide the valve upward in a straight line. The roller *C* is of hardened steel as is also the cam face, but despite this, wear occurs and when it does is likely to effect the lift of the valve. To take account of this and always give the same amount of lift to the valve, the push rod is fitted with an adjustment at its upper end. This, marked *D* in the figure, consists of a bolt threaded into the upper end of the push rod and having a hardened steel insert in its central point of contact with the end of the valve stem. To retain the correct relation between the two, when it has once been obtained, a lock nut is utilized. While this is actually the exhaust valve, the same construction applies to the inlet valve mechanism, the parts of the two being interchangeable. This same line of reasoning and this same method of procedure, when followed in the case of the *exhaust cam,* will result in giving it the correct shape.

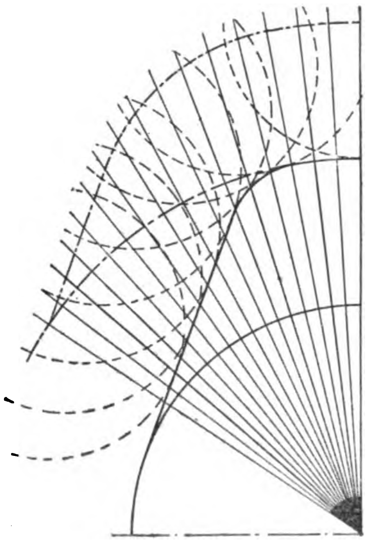


Fig. 3. Straight-Sided or Ordinary Cam.

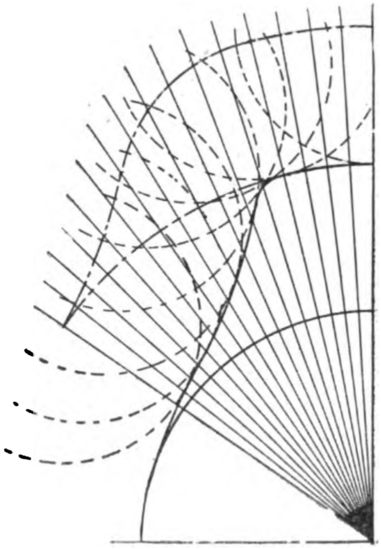


Fig. 4. Lay-Out for Uniform Acceleration Cam.

It has many times been tried and still more often urged that the straight surface of the side of the cam is not conducive to the best results, because of the fact that when the first straight portion of the cam surface strikes the cam roller it does so with so much force that it tends to wear the latter in that direction. As for the receding face, it has been urged that the ordinary closing of the valve is too slow, and that the straight surface, as shown in Fig. 3, could be altered so as to allow of speeding up the downward movement of the valve. This idea works out into a curve, Fig. 4, the back of the surface being hollowed out so that as soon as the cam roller passes the center it drops vertically, due to the tension of the spring. This method has been tried but without success.

What Good Modern Practice Shows. A more modern way, which is fast becoming universal, is to use straight sides for the cams and take advantage of rapid closing in another way, the benefits of which more than offset the benefits of the old way, while having no corresponding disadvantages. In the ordinary automobile engine running at 1,000 revolutions per minute, the gases are traveling into the cylinder at the rate of 5,000 to 6,000 feet per minute, and traveling out at from 7,000 to 10,000 feet per minute. At this tremendous speed, the gas inertia is very high, and experiments go to show that the gases by means of this inertia will continue to force their way into the cylinder even against the return motion of the piston. So it is now common practice to hold the inlet valve open about 20 degrees on the up-stroke of the piston, which results in a much larger piston charge. The same practice is carried out with the exhaust, but as the pressure is higher, so large an angle is not necessary. These actions take place on the *back*, flat side of the cam surface, and have given to the high-speed automobile engine

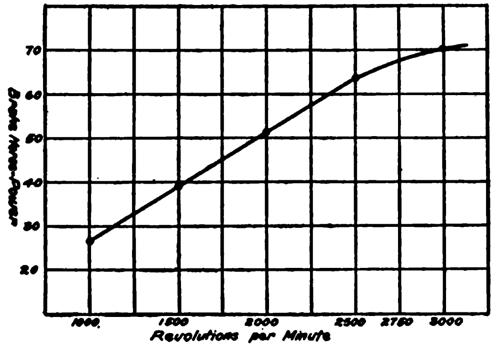


Fig. 5. Power Curve of an English Engine with Superior Cams.

a larger charge and a more complete scavenging effect, resulting in more power and speed from the same sized cylinder.

As proof of this statement, the power curve of an engine of but 4-inch diameter of cylinder is shown in Fig. 5. This size of four-cylinder engine would be rated by any formula at about 25 horsepower at the maximum speed, and a commercially obtainable type in this size would doubtless be guaranteed to deliver between 20 and 25 horsepower. This engine, built for racing purposes, displays a power curve which continuously rises, a speed at which it would turn downward not having been obtainable in the tests. This curve shows also that the maximum power obtained was over 70, which is nearly three times the power of the ordinary engine of this same size. This result is ascribable to superior valves and superior attention to the valve angles as governed by the cams.

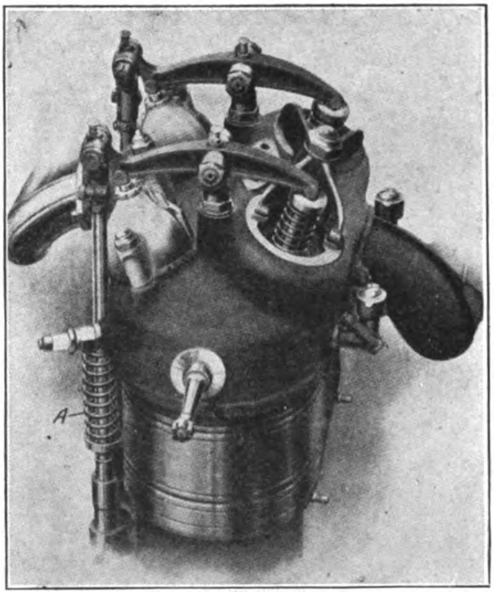


Fig. 6. Engine with Spring *A*, Doing Work of Cam. Formerly made by De Luxe Motor Car Company.

When it was stated that but two valves per cylinder were ordinarily used, with one cam for each, the majority case was spoken of. But, as it is a fact that there are other cases which differ from this, it would not be fair to close the subject without mentioning them. Thus, the most prominent advocate of air cooling in this country and the world, the H. H. Franklin Manufacturing Company, uses three valves, and, consequently, three cams per cylinder. These three are: the ordinary *inlet;* the usual *exhaust;* and the additional *auxiliary exhaust.* As for the cams themselves, aside from their number, they do not differ from the ordinary.

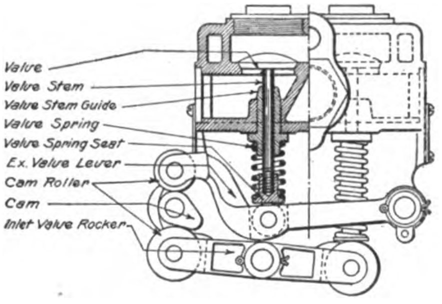


Fig. 7. Valve Motion with One Cam Opening Both Valves.

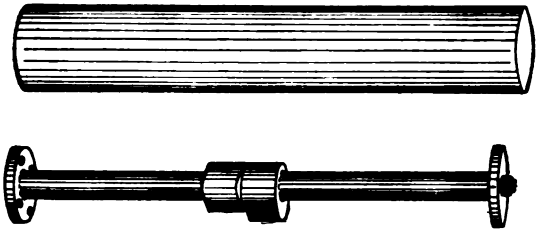


Fig. 8. Cam Shaft and Chrome Nickel Steel Billet from Which It Was Made.

One Cam per Two Valves Influences the Shape. A case in which the cam does differ is that of the use of two overhead valves operated from a single cam shaft, Fig. 6. This practice originated with the F. I. A. T. Company, which brought it out for racing use only, where it was particularly useful in that it halved the weight of the cam shaft, as well as saved much weight in push rods, etc. Later, this was taken up by other firms for regular use, although the company which first brought it out has never done so. In our own country, the device was adopted by the Pope Toledo Company, the Stoddard-Dayton, De Luxe, and others. The work of opening the extra valve is done by a spring, *i. e.*, a depression in the back of the cam allows a strong spring to pull the push rod down, by which process the valve stem is depressed and the valve opened. In Fig. 7 may be seen a variation of this method, the one cam operating both valves but being placed alongside of instead of on top of the cylinder castings. This form was used on the Oldsmobile first four-cylinder cars. Fig. 8 shows how the cams for an overhead cam shaft may be machined up in a single piece, a pair of shafts like the one shown constituting the cam shaft of a four-cylinder engine. These are bolted together, the holes in the flange being plainly discernible. This shaft is made of very high-grade material and the method of making it in two pieces is resorted to in order to save as much of the material as possible. This method of procedure, of course, calls for a different treatment of the cam, for not only must the depression be put in its proper place, but it must be of the correct depth, and the point of its beginning and ending must be correctly determined.

When any kind of a cam-follower is used, differing from the usual direct lift push rod, as shown in Fig. 9, this may or may not affect the shape of the cam. Usually it does not, so that the shape does not have to be taken into account. Ordinarily these followers are used to prevent side thrust on the push rod guide, the follower itself taking all the thrust and being so designed as to be readily removable or adjustable, to take care of this. In cases where this does not obtain, the object usually sought is the removal of noise. The two objects may be combined as in the case shown in Fig. 10. This represents the cam and valve action of the famous one-cylinder French car, *Peugeot*. The enlarged view of the cam mechanism is added to the illustration to make clear the action, which is that of one cam operating both the exhaust and the inlet valves through the medium of a pair of levers, upon which the cam works alternately.

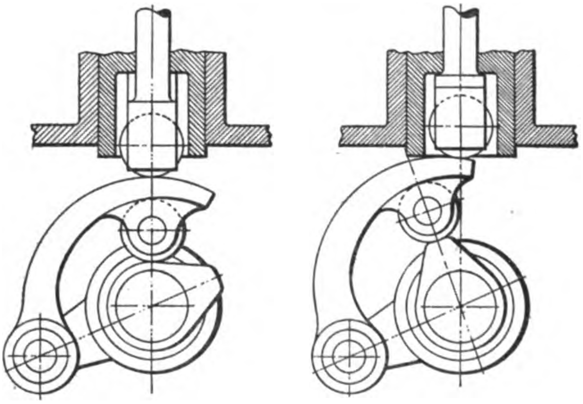


Fig. 9. Cam Design with Follower between Cam and Roller.

It sometimes happens that the same maker does not use the same cam shapes upon all of his engines, although what is good practice in one case, would certainly appear to be good practice in another. That this does not hold is shown by Fig. 11 and Fig. 12, which illustrate the practice of the Maxwell-Briscoe Motor Car Company, previously referred to. Fig. 13 shows a double form of cam used to facilitate starting.

Difficulties Met with in Making Cams. Time was when the production of a good, accurate cam shaft was a big job in any machine shop, well-equipped or otherwise, and represented the expenditure of much money in jigs, tools, and fixtures. Now, however, the machine-tool builder has come to the rescue of the automobile manufacturer, and special tools have made the work easy. So it was with the production of the shaft with integral cams; this used to be a big undertaking, but today, special machinery has made it an easy

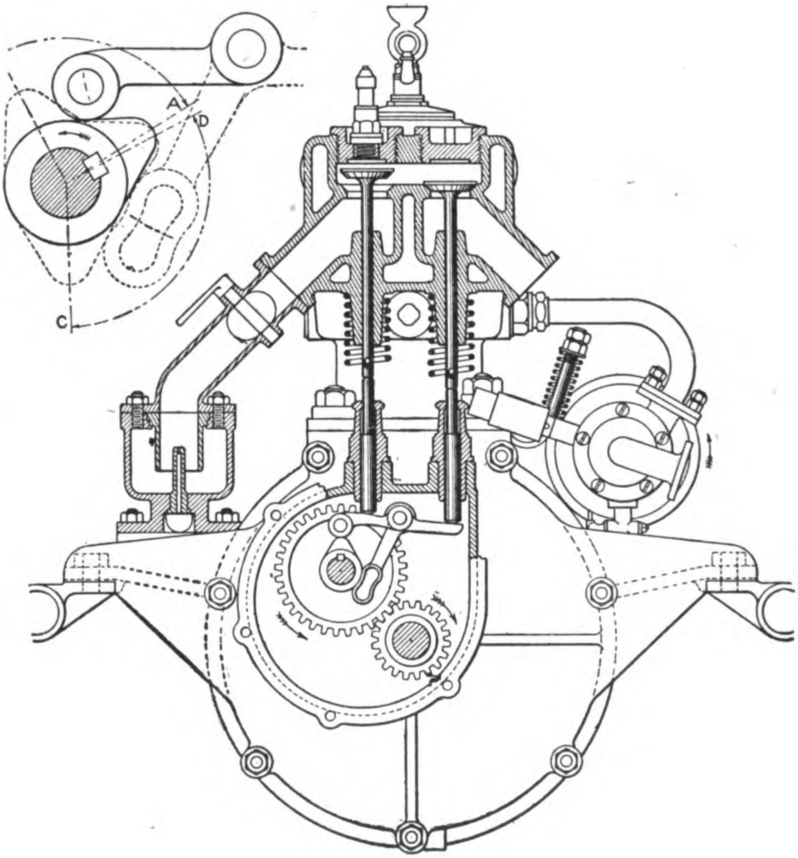


Fig. 10. Peugeot (French), Single-Cylinder Engine

matter. The illustration, Fig. 14, shows a cam milling machine, and Fig. 15 and Fig. 16, some of its product. This is now the favored way of putting out engines, for the integral cams and shaft have the advantage of much lower first cost, and with proper hardening, will last fully as long as those made by cutting the cams separately and assembling them in their proper position on the shaft.

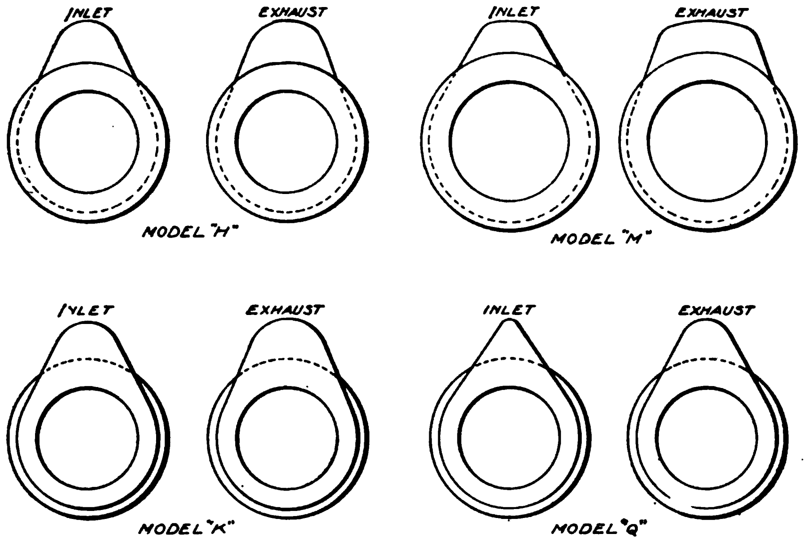


Fig. 11. Maxwell Cams.
Maxwell-Briscoe Motor Car Company, Tarrytown, N. Y

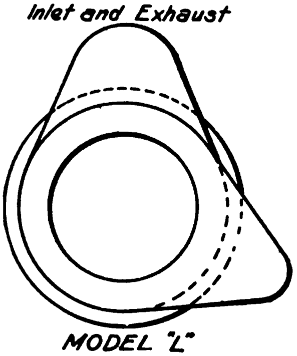


Fig. 12. Maxwell Inlet and Exhaust Cams.

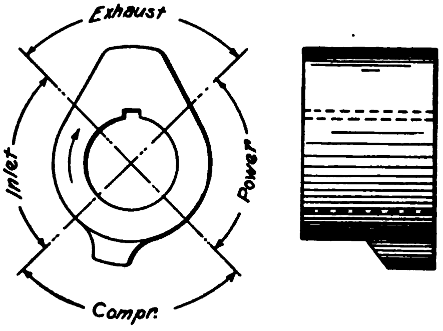


Fig. 13. Double Cam for Easy Starting.

Old Way Required More Accurate Inspection. With the old method of making the cams and shaft separate, the amount of inspection work was very great and represented a large total expense in the cost of the car. Thus, it was necessary to prove up every cam separately, as well as every shaft, and later, the cams and shaft assembled. One of the forms of gauges used for inspecting cams is shown in Fig. 17. It is in two pieces, dovetailed together. This allows of the testing of many shapes of cam with but one base piece and a number of upper or profile pieces equal to the number of different cams to be tested. To test, the cam is slipped into the opening, and if small, the set screw forces it up into the formed part of the gauge, showing its deficiencies; while if large, it will not enter the form.

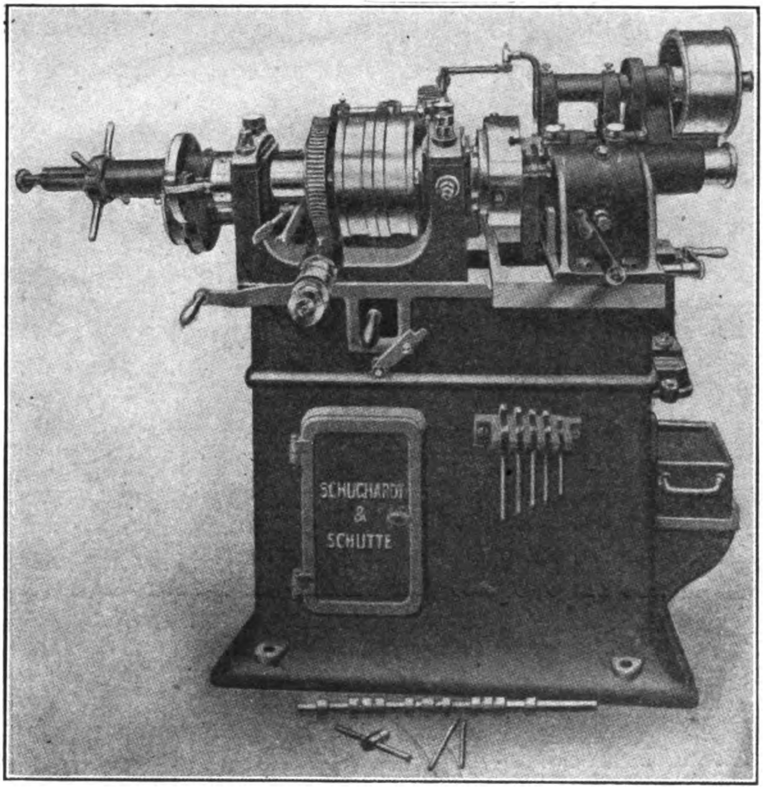


Fig. 14. Milling Machine for Making Cam Shafts with Integral Cams.

Sliding Sleeve. A method of avoiding cams and with it all cam troubles, is the use of a *sliding sleeve* in place of a valve, slots in the sleeve corresponding to the usual valve openings, both as to area and timing. The sleeves may be operated by means of eccentrics, or by various lever motions. An additional way is the direct drive by means of a gear, a worm and gear being used for the purpose. An example of the application of this to a French two-cycle engine is shown in Fig. 18, although there is nothing in its construction which would prevent its use on the more usual four-cycle engine,

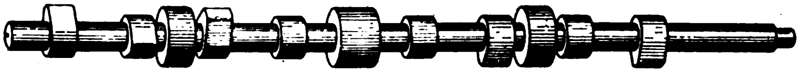


Fig. 15. Cams Integral with Shaft—Milling Machine Job.

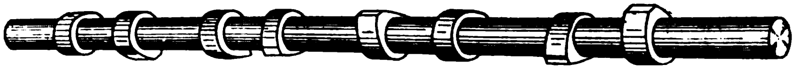


Fig. 16. Another Cam Shaft with Integral Cams.

In this figure, P is the usual crank shaft, Q the large end of the connecting rod K, while A is the piston and R the crank case, no one of these differing from those in other engines. On the crank shaft there is a large gear F, which drives a smaller gear E, located on a longitudinal shaft above and outside of the crank case. On this shaft is located a worm gear D, which meshes with a worm C formed integral with the sleeve surrounding the piston B. Aside from this worm gear, the sleeve is perfectly cylindrical, being open at both ends. It is placed outside of the piston between that and the cylinder walls. At its upper end, it has a number of ports or slots cut through it, which are correctly located vertically to register or coincide with the port openings in the cylinder walls, when the sleeve is rotated. At H is seen one of these—the exhaust—while 90 degrees around from

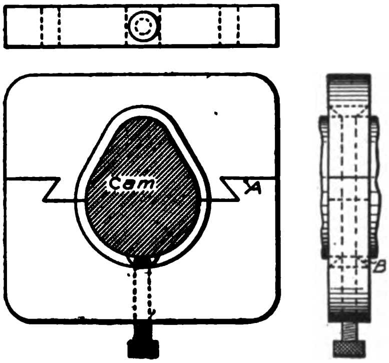


Fig. 17. English Cam Gauge.

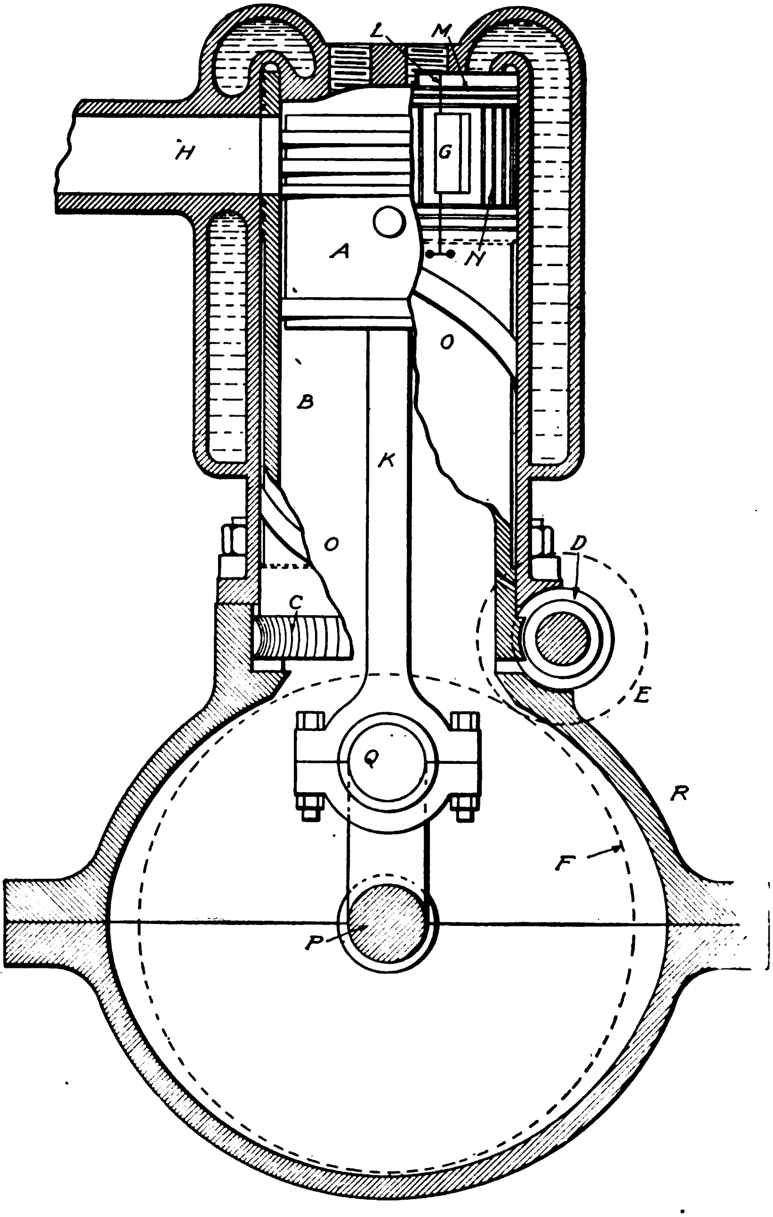


Fig. 18. Section through Ledru (French) Camless Engine. The Rotary Gear-Driven Sleeve Displaces All Cams.

it and hence invisible in this figure, is a similar port for the inlet. As the crank shaft rotates, the side shaft carrying the worm is constrained to turn also. This turns the worm which rotates the worm wheel and with it, the sleeve. Thus, the openings in the sleeve are brought around to the proper openings in the cylinder, and the combustion chamber is supplied with fresh gas, and the burned gasse carried away at the correct time in the cycle of operations.

With a motor of this sort, the greatest question is that of lubrication. The manner in which it is effected in this case, is by means of the large wide spiral grooves shown at *O O*, and the smaller circular grooves at the upper end *M*. This problem is also rendered more easy of solution by the machining of the sleeve, as during this operation, much metal is cut away along the sides, so that the sleeve does not bear against the cylinder walls along its whole length, but only for a short length at the top and a still shorter length at the bottom.

The same result is accomplished in a slightly different manner by the use of a combination of eccentrics and levers, as is indicated in Fig. 19, showing the idea of a New York inventor, Osborn. This scheme places upon the usual cam gear an eccentric pin, upon which is located an eccentric rod or lever *A*. The latter is pivoted at its lower end to a pin *B*, which pin is a part of a sliding member *C*, carrying upon its upper part a piston rod *E*. This slide reciprocates, according to the impulse imparted to it by the eccentric *A*, being guided by the slides *D*, which are fixed to the side of the crank case.

Upon the upper end of the piston rod *E*, is fixed a piston *F*, and slidably mounted around the whole is another piston valve *J*. The former is always moved by the rod, while the latter is only moved upward by the collar at *I*, its downward motion being produced by a spring, not shown. *G* is the combustion chamber into which it is desired to lead the fuel mixture, and out of which the exhaust gases must afterwards be taken through the exhaust pipe *H*. *K* is the inlet pipe, *L L* are the inlet ports, and *M* is the exhaust port. Unfortunately, this drawing shows the piston at the top of its movement, which would be more clear were it at the bottom. On the down stroke of the inner piston, moved positively by the eccentric, the exhaust gases rush down and out. On the same stroke, the inflowing gas fills the passage around the outside of this, so that when the exhaust stroke is completed, and the piston has risen so as to uncover the lower edge of the port through the walls *O*, the

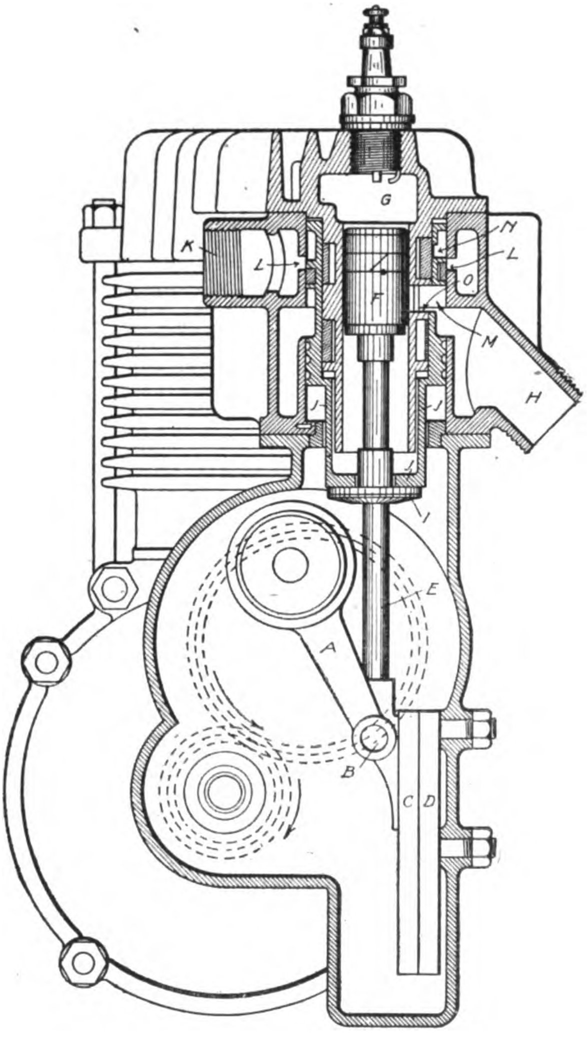


Fig. 19. Osborn Valve Motion without Cams.

gases are free to rush in, impelled by the suction of the motor piston. In the meantime, the rising outside sleeve has covered the exhaust port *M*, so that none of the mixture may escape to the outside air.

Much publicity has been given of late to the product of a Chicago man, Knight by name. In this, a regular four-cylinder, four-cycle engine, the valves consist of a pair of concentric sleeves, openings in the two performing the requisite functions of valves in the proper order. These sleeves, as Fig. 20 shows, are actuated from a regular cam shaft—running at half the crank-shaft speed and driven by a silent chain—by means of a series of eccentrics and connecting rods. In the figure, *A* is the inner and longer sleeve carrying at its lower end the groove or projection *C*, around and into which the collar actuating the sleeve is fixed. This collar is attached to the eccentric rod *E*, which is driven by the eccentric shaft shown. The collar *D* performs a similar function for the outer sleeve *B*.

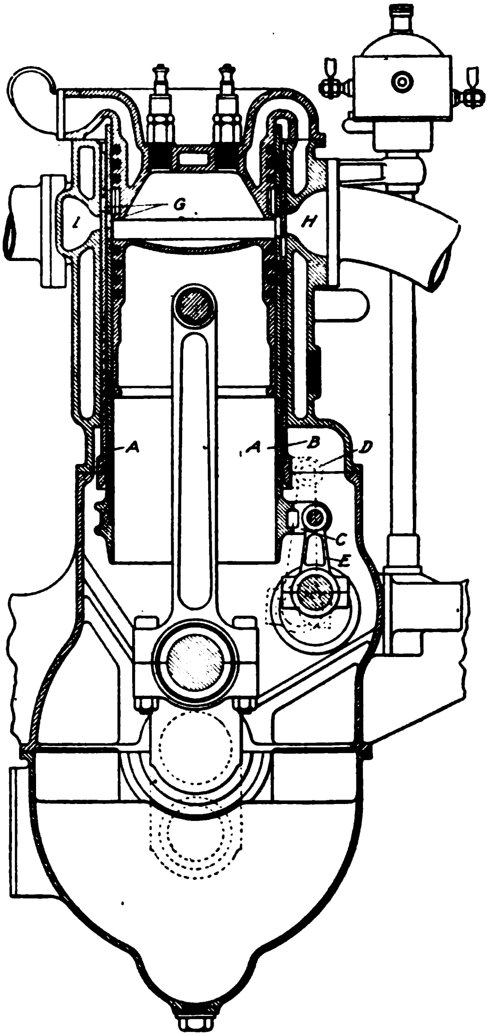


Fig. 20. Knight Engine. Eccentrics and Sleeves Replacing Cams and Valves.

At the upper ends of both sleeves, slots *G* are cut through to serve as connection between the inside and the outside. These slots are so sized and located as to be brought into correct relations to one another and to the ports in the cylinder walls, exhaust at *II* and inlet at *I*, in the course of the stroke.

While at first thought, this engine might be considered as lacking in power from the fact that the sliding sleeves would eat up more power in internal friction than would otherwise be gained, the fact remains that a very severe and unusually thorough test of an engine of this type, made by the Royal Automobile Club of England, an unbiased body, proved that for its size, the power output was greater than many engines of the regulation type. Moreover, the amount of lubricating oil was small, just the contrary of what would be supposed.

This test was unusually severe and resulted as shown by Table III.

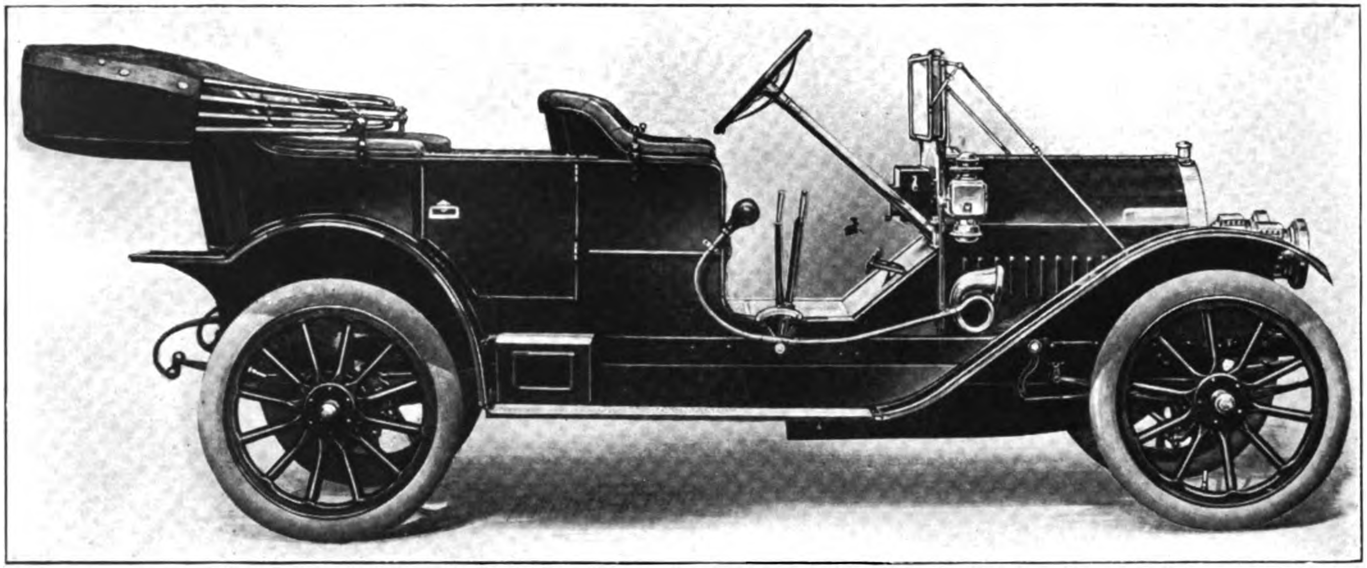
TABLE III

Royal Automobile Club's Committee Report on Knight Engine

Motor horse-power—R. A. C.		38 .4	22 .85
Bore and stroke		124 by 130	96 by 130
Minimum horse-power allowed		50 .8	35 .3
Speed on bench test		1200 R. P. M.	1400 R. P. M.
Car weight on track		3805 pounds	3332 .5 pounds
Car weight on road		4085 pounds	3612 .5 pounds
Duration bench test		134 hours 15 min.	132 hours 58 min.
Penalized stops		None	None
Non-penalized stops		Five—116 min.	Two—17 min.
Light load periods		19 minutes	41 minutes
Average horse-power		54 .3	38 .83
Final bench test		5 hours 15 min	5 hours 2 min.
Penalized stops		None	None
Light load periods		15 minutes	1 minute
Average horse-power		57 .25	38 .96
Mileage on track		1930 .5	1914 .1
Mileage on road		229	229
Total time on track		45 hours 32 min.	45 hours 42 min.
Average track speed		42.4 M. P. H.	41 .8 M. P. H.
Fuel per brake horse-power per hour	First bench	.679 pt.	.739 pt.
	Test	.613 lb.	.668 lb.
	Final bench	.599 pt.	.749 pt.
	Test	.541 lb.	.677 lb.
Car miles per gallon	On track	20 .57	22 .44
	On road	19 .48	19 .48
Ton miles per gallon	On track	34 .94	33 .37
	On road	35 .97	31 .19

After the test was concluded, the sleeves, Fig. 21, were found to still show the original marks of the lathe tool. This proved conclusively that the principle of this type was right, for the tests were equivalent to an ordinary season's running.

In Fig. 21, the sleeves are marked with the same letters as in Fig. 20. *A* being the inner and noticeably longer one, while *B* is the outer and shorter one. At *C* and *D*, the attaching collars and



THE HUDSON ''TWENTY TOURING CAR

The Hudson Motor Car Co., Detroit Mich

the pins on which the connecting rods are attached may be seen, while at *G G* are shown the slots which serve as valve ports. *J J* are oil grooves for the purpose of carrying oil around the sleeves, and thus rendering their movement up and down easy.

The inventor of this last-named form of engine had it in mind to bring out an engine that would be economical of fuel and in this way reduce the cost of upkeep. As to its fuel economy, only time can tell that, but the design is such as to require a regular carbureter and fuel vaporizing system just as other engines do. This fuel vaporization problem is one which has agitated automobile men ever since the time of Benz, Daimler, and other pioneers. Their first problem was one of carburetion, and today manufacturers argue over the best type and form of mechanism to do the same work, some stating that it is better to buy from a carbureter specialist, while an equal number maintain that it is better to make it themselves and after their own ideas.

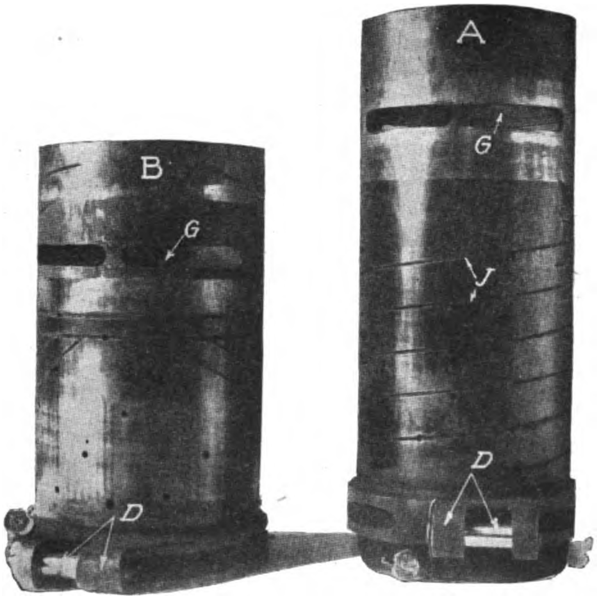


Fig. 21. Sleeves Which Replaced Valves on Knight Engine, After 137-Hour Bench Test and 2,200 Miles on the Road.

CARBURETERS

Classified according to structure, operation, and principle, all fuel vaporizing devices may be divided into three main classes, which are as follows:

1. The surface carbureter.
2. The ebullition or filtering carbureter.
3. The float feed or spraying carbureter.

As most of the modern devices come in the last-named class, it will be sufficient to speak of the other two briefly. The early devices were mainly of the surface type, in which the air passed over the surface of a body of fuel, picking up some of it, Fig. 22. Another early form circulated the air around gauze, wicking, or other surface saturated with fuel, Fig. 23. Benz used a vaporizing device of this sort in his earlier machines. Both of these methods are in use today, but in combination, and not as the sole source of gas.

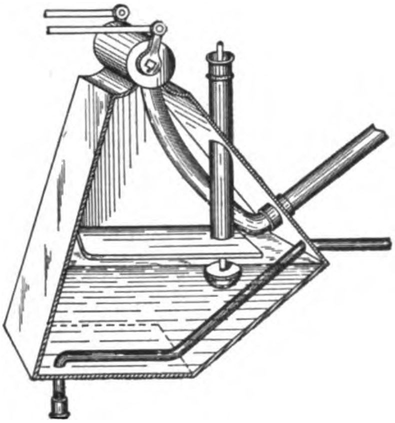


Fig. 22. Original De Dion Surface Carbureter.

Another very old device is called the *ebullition* or *filtering carbureter.* In this, air was forced through a body of liquid, which entered at the bottom and in its passage to the top absorbed small particles of the fuel. Daimler began with this style, but later abandoned it in favor of the Maybach float-feed spraying arrangement, which was the prototype of the form now in prevailing use. The filtering scheme is, however, still used.

A fourth, and the most common, basis of operation, is the *spraying* or *atomizing* of the liquid through a very fine nozzle, the vapor being picked up by the inrushing air. The first of this type, the *Maybach*, Fig. 24, was remarkable, in comparison with its modern successor, principally for its simplicity. There was a float, controlled by the amount of liquid, and a nozzle. The air entered around the nozzle and, mixing with the fine spray of fuel in a chamber directly above the cylinder, was drawn from there into the combustion chamber.

Although simple, it was also crude and the heat from the cylinder doubtless had much to do with its success. The nozzle was large, as such sizes go today, but in spite of all these defects it worked, and worked better than anything that preceded it.

Defects in the Original Are Not Found in Modern Types. The original carbureter had no adjustment; the opening in the casting measured the amount of air; the size of the nozzle measured the amount of the fuel and the fineness of the spray. There was no means of regrinding the float valve, and thus no way of assuring an even and continuous flow of fuel. The modern adjuncts of the original Maybach device consist of remedies for these defects, and, in addition, a proper means of balancing and adjusting the float.

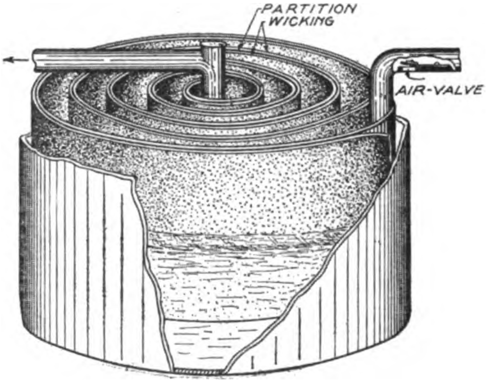


Fig. 23. Wick Vaporizing Device.

To pick out a modern carbureter at random, take the one shown in Fig. 25. Like its ancestor, this has a gasoline chamber into which the fuel is admitted by the action of a float, first passing through a strainer. From the float chamber the liquid passes up to and through the spraying nozzle. The weight of the float is so calculated that the level in the final nozzle is just 1 millimeter (0.04 inch) below the top. This insures that there will always be fuel there for the air suction to draw off. As the chemical action of changing a substance from a liquid to a gas is usually accompanied by the absorption of heat it is

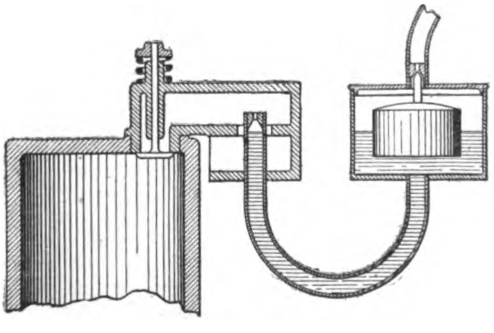


Fig. 24. Original Maybach Carbureter.

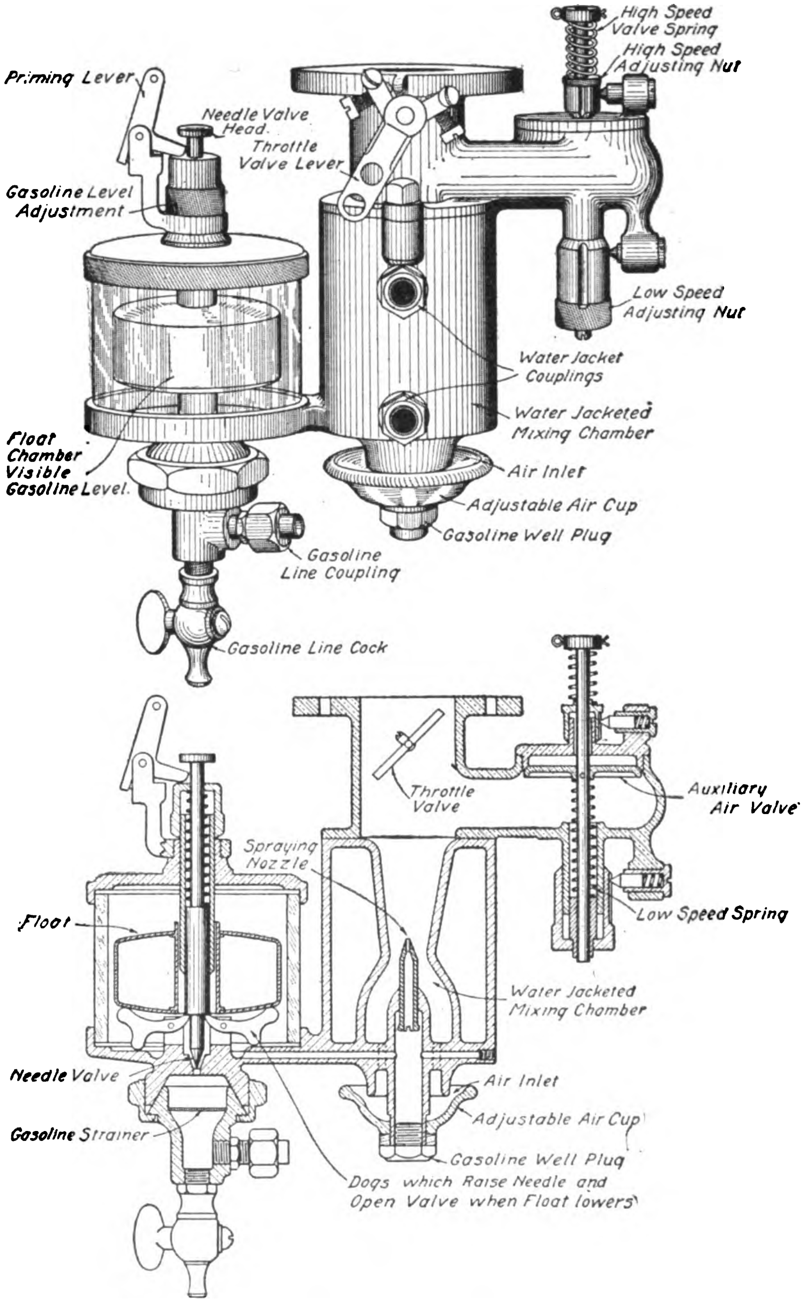


Fig. 25. **American Carbureter with Venturi Shaped Mixing Chamber.**
Stromberg Motor Devices Company, Chicago, Ill.

advisable to supply a reasonable proportion of this and thus assist the change of form. In the older Maybach, this was inadvertently done by placing the whole apparatus in close contact with the hot cylinder. In the modern carbureter, placed some distance from the heated portions of the engine, this additional heat is supplied by the jacket water. An alternate scheme is to preheat the air supply by a special pipe from the exhaust manifold.

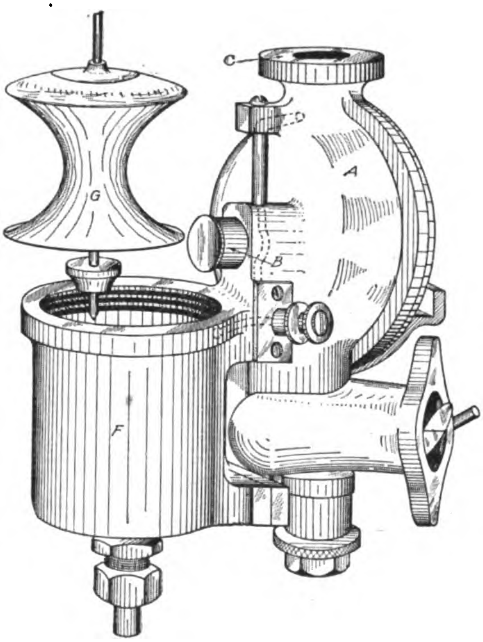


Fig. 26. Gillett-Lehmann Carbureter.

From this mixing chamber the mixture of air and gasoline vapor passes upward into a secondary mixing chamber. This communicates with the inlet pipe through the medium of the throttle valve. Into the latter chamber, the auxiliary air supply (when used) has access through the auxiliary air valve. This comes into action on very high speeds when the engine is pulling very strongly, for which the proportion of gasoline to air is liable to be too large, so the auxiliary opens, admits more air, and thus dilutes the mixture.

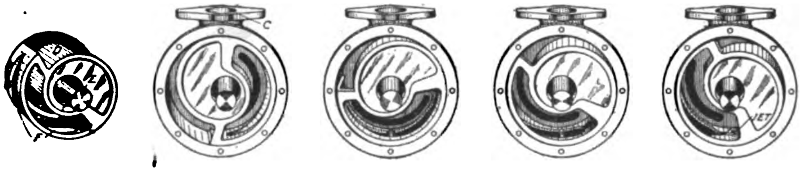


Fig. 27. Gillett-Lehmann Throttle.

Another form of carbureter which embodies many novel ideas is illustrated in Fig. 26 and shown in detail in Fig. 27. In the former, *A* is the casing of the throttle valve, which is the principal feature of this device. *B* is the inner end of the throttle valve shaft, while *C* is the flanged pipe for attachment to the inlet to engine. *F* is the float chamber, not different from the ordinary one, while within it, the float *G*, hollow metal, works up and down just as do hundreds of others.

In Fig. 27, however, the throttle valve is shown in its casing, one side being cut away for the sake of clearness. In this *D* is the throttle and *E* the end of the shaft, while *C* indicates the same flanged connection as before. The throttle *D* has a spiral exterior, and being set into a circular hole, of which just the tip of the spiral is a close fit, there is always an opening around the outside of it and between it and the casing. The air enters at the center of the bottom, around the gasoline spray nozzle. In one side of the throttle is cut a slot of varying width, the ends being straight for a very short distance and of a width just equal to the size of the gasoline nozzle. In the extreme left-hand view the throttle is removed from the casing, showing the slot *F;* while in the second view, the throttle is placed in the casing, but so turned that the passage to the engine is cut off. Air may enter as well as gasoline, the nozzle projecting through the small end of the slot at the bottom.

With a quarter rotation to the right, as shown in the third view, a slight opening is formed at the top so that the mixture may be drawn into the cylinders in small quantities, the nozzle being entirely opened and uncovered. In the fourth view, an additional turn has brought the spiral exterior of the throttle valve around to such a point as to leave the maximum possible opening between itself and the casing at the top. This, then, is the full opening, both gasoline and air openings being also wide open. Turning a little further leaves the outlet about as large as before, but restricts the gasoline spray, leaving the air unchanged. This latter is the position which would be assumed for full speed on a level road, the over-rich mixture being detrimental in this case.

Throttle Valves in General. Whatever the character of the mixture in the carbureter, it is admitted to the cylinder by the throttle valve, which may take the form known as the *butterfly.* This is a flat piece of sheet metal, preferably brass, attached to a suitable shaft with an operating lever on the external end. Not all throttles,

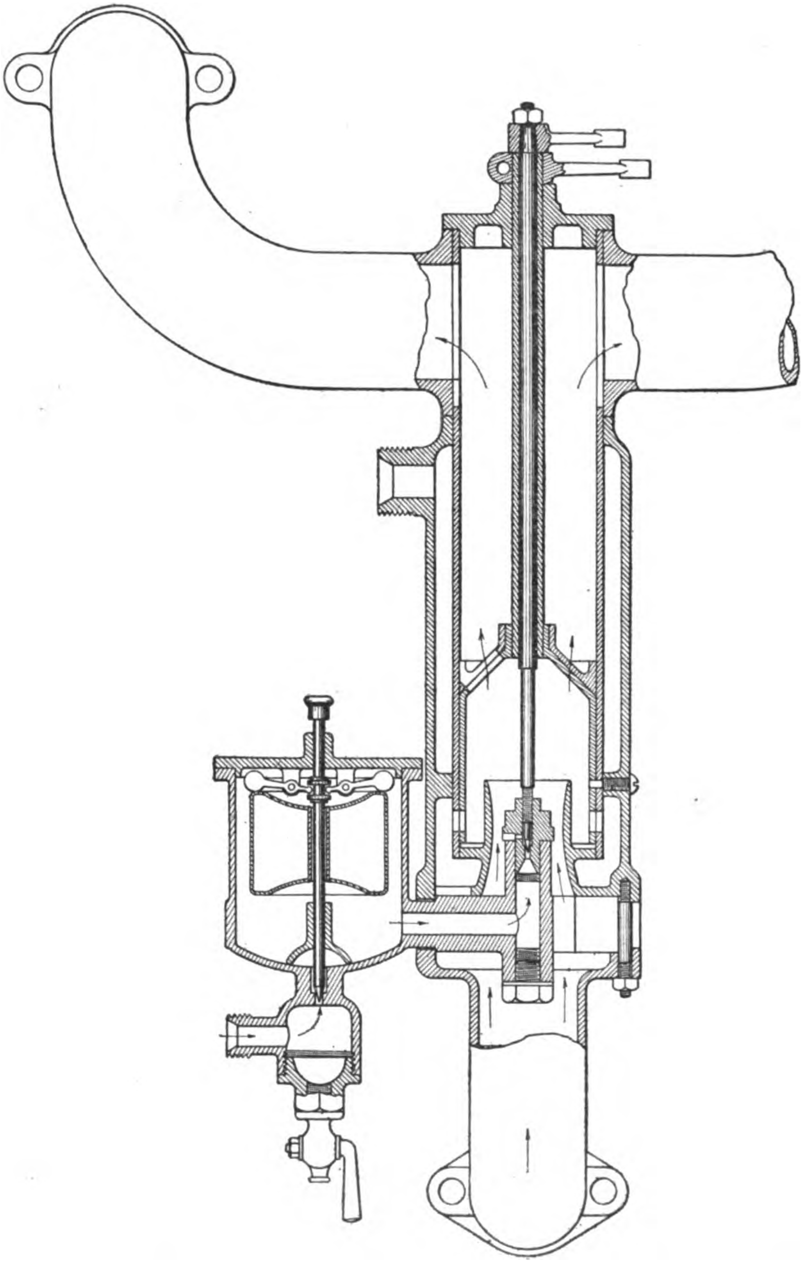


Fig. 28. Carbureter and Inlet Pipe of Gaggenau (German) Commercial Vehicles.

however, are of the butterfly type, there being fully as many of the *piston* type. This consists of a cylindrical ring or shell of metal, which is free to slide in a corresponding cylindrical chamber. In the walls of the latter are a number of apertures or ports which the longitudinal movement of the piston either uncovers or covers as the case may be. Sometimes to facilitate this action, the sides of the piston are grooved or notched, but this does not alter the principle of sliding a cylinder within another cylinder to cover or uncover certain ports in the cylinder walls. This form of throttle is used and advocated by such prominent firms as Napier, Panhard, Krebs, and other equally famous constructors.

Floats. Another feature of the earlier forms of carbureters, which was soon found to be in need of a change, was the arrangement of the float. In Maybach's original vaporizer, there was no means of balancing the float; consequently, there was no way of preventing wrenching and breaking of the needle valve spindle. As this disarranged the gasoline supply, it was very important and received early attention. In addition, there was the necessity for reliable devices to regulate the supply of air and gasoline spray from the nozzle, either by original adjustment or by means of a governor or else effecting by hand a constant variation to meet constantly varying conditions of engine demands.

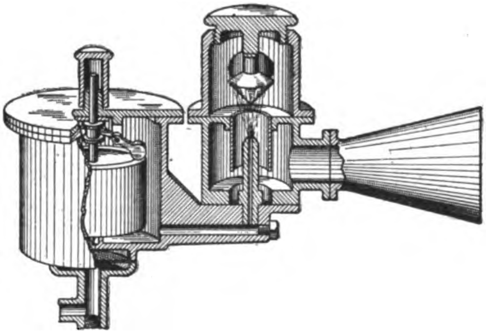


Fig. 29. Phoenix-Daimler (French) Conical Spray Interceptor.

These additions to the original form caused some trouble. The ordinary way of managing the balancing of the float, while it may be the cause of trouble at times, is a very simple one. The float is of exceeding lightness, whether made of cork or metal. With the in-flow of gasoline in liquid form this float rises and in so doing it strikes against a pair of small pivoted levers near the top of the float chamber, Fig. 28; the other ends of both of these rest upon a form of shifting collar on the needle valve stem. So, when the float rises above a certain level, it automatically shuts off the flow of gasoline, by pressing against the pivoted levers, which, in turn, act against the stem and press it down until the flow is cut off. The float will stay up until the suction of the engine has lowered the gasoline level so that the dropping of the float releases the levers which raise the needle valve off of its seat. The gasoline flow is thus automatically regulated by this balanced float arrangement.

Adjustment of Air Supply and Gasoline. Probably no one detail of the whole list of carbureter parts has caused and still does cause more difference of opinion than the source of and adjustment of the air supply, and its companion, the adjustment of the gasoline spray. The latter drew attention long before the former did; in fact, the former is more of a modern appliance. The fuel spray was investigated long ago; thus, in the Phoenix-Daimler, Fig. 29, the gasoline spray had no adjustment, but the size and location of the level of the nozzle were fixed. The spray itself, however, received special treatment, being projected against a conical spray deflector, which served to break up the column into finer and more diffused particles. In this way, greater vaporizing action was gained.

Longuemare, the famous French carbureter expert, had a different method, Fig. 30, which consisted in dividing the spray, before the air struck it, into a circular column of finely divided particles. These were then easily picked up by the incoming air, which in its upward passage was further diluted by the addition of more air. The latter was added at a point where the carbureted gas was obliged to turn a right angle, at which any remaining particles of pure gas would have been thrown off by centrifugal force. The down-coming stream of extra air met these particles and by carrying them along prevented what would otherwise have been a waste of fuel. This carbureter has long been noted for its fuel economy.

In Fig. 30, *A* is the float chamber, containing the hollow metal float *B*. Gasoline enters from below, *I* being the gasoline pipe connection, *J* the drain cock, and *H* the gasoline chamber with the needle valve at the top. At the top of the float chamber the small lever for priming may be seen at *E*, while *C* is the removable cover, with the bushing *D* covering the end of the needle valve shaft. The gasoline flows across the horizontal passage to the vertical one, in which the spray nozzle is located. This spray is formed by the fuel

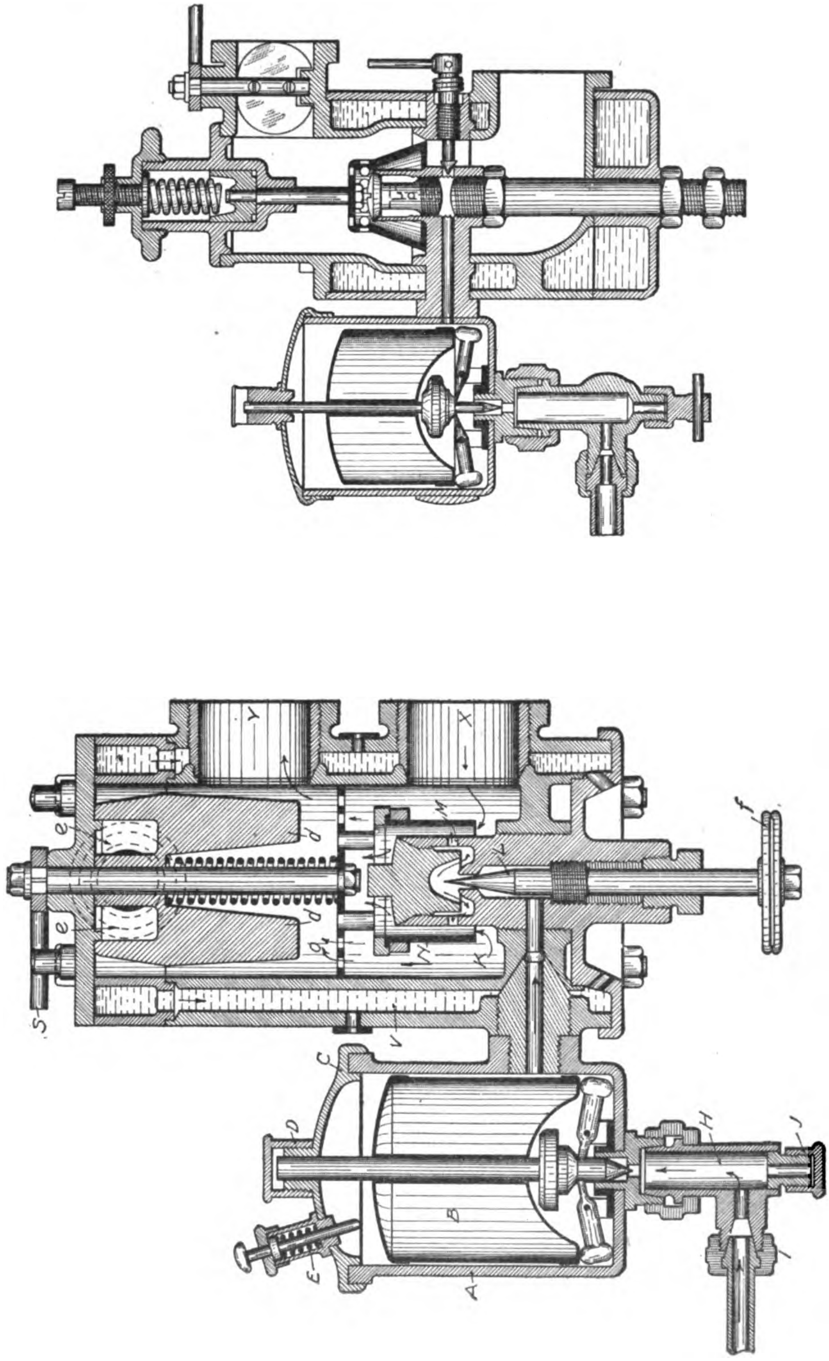


Fig. 30. Longuemare (French), Arranged for Alcohol, and King (American License), Arranged for Kerosene.

passing through the small orifice formed between the restricted upper part of the vertical passage and the point of the *needle L.* Just above this, so that the spray impinges upon it, is placed an inverted cone, which deflects the gasoline spray down again and outward through short horizontal apertures *M.* Around these openings is placed a hollow cylindrical shell *N* open at the top and with holes *K* in the bottom. The air rushes in through these latter, and picking up the gasoline spray, passes along out of the top of the cylinder, being augmented outside by additional air rising around the outside of the cylindrical shell *N.* The mixture then passes upward through the diaphragm filled with holes *O*, and thence into the pipe to the cylinders *Y.* *X* is the air inlet. The auxiliary air enters at the top, its entrance being controlled by the balance established between the weight with two arms *d d* and the central spring. The two small openings *e e* indicate the location of the auxiliary air pipe, while *v* is the water jacket—at the time this particular model was brought out, however, it was used as a hot-air jacket, instead of the more modern hot water. The lever *S* controls the amount of mixture admitted, while the hand wheel *f* governs the adjustment of the needle *L.* In the right-hand corner of Fig. 30, the King carbureter is shown. This was an American copy of the Longuemare, but made under license.

So, too, this same make is noted for being among the first to use a water jacket around the vaporizing chamber. The conversion of a liquid into a gas is an endothermic reaction and requires heat for its completion. If this be not supplied by external means, it will be extracted from surrounding objects. This accounts for the frost which gathers on the outside of the mixing chamber of carbureters which do not have a water jacket or other source of heat supply. The heat is abstracted from the air so rapidly that the moisture in the air is frozen, appearing as frost on the outside of the carbureter.

As for an auxiliary air valve, this has always been a source of discussion, its opponents claiming that it means extra parts, and therefore more adjustments and more sources of trouble; while those favoring it say that without some additional means of this sort for diluting the mixture at high speeds, it is impossible to run the engine fast, as high speed will then mean an over-rich charge. Be that as it may, the fact remains that the weight of opinion lies with the auxiliary valve.

Usual Form of Auxiliary Air Inlet Valve. The auxiliary air inlet usually consists of a simple valve opening inward, held in its place by a spring of a certain known tension. The strength of the spring is carefully determined so that at the proper moment, when the motor requires more air in proportion to the amount of gasoline used, the valve will open just enough to allow the required amount of air to enter. It will be seen that the time and the amount of opening will be controlled by the speed of the engine, *i. e.*, by the amount of suction produced by the movement of the piston in the cylinder. Of course, as the engine speeds up, there is a greater piston displacement to be filled per minute, and therefore it is necessary to supply a greater amount of mixture. Upon changing speed suddenly from, say, 500 revolutions to 900 or 1,000, the carbureter not having this device will *not* give a uniform mixture immediately, and, in fact, it might require a new adjustment of the gasoline flow in order to supply the right amount of fuel. What the auxiliary air inlet actually does, then, is to automatically control above a certain point the amount of air admitted, thereby always maintaining a homogeneous mixture. In order to prevent any chattering of the valve or rapid changes in the air supply, a *diaphragm* or *dashpot* is sometimes used in connection with the valve. Fig. 31 and Fig. 32 show types where the former method is used. Fig. 33 is an example of the latter.

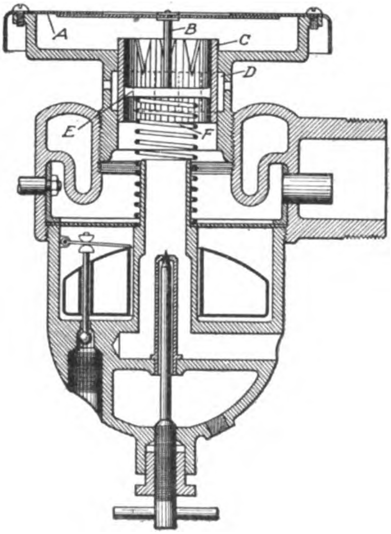


Fig. 31. Diaphragm to Control Auxiliary Air Admission.

In Fig. 31, instead of using a regular valve, a piston valve is introduced which, however, accomplishes the same result in a slightly different way. This carbureter and its action will be rendered more clear by a little explanation. Referring to Fig. 31, the diaphragm *A* is mounted upon the top of the stem *B*, which carries, further down, the piston throttle *C*. This is open at the top end, but near the bottom has a partition *E* across it. The top edge of the throttle has notches cut in it of triangular shape. When the motor demands are such as to cause a partial vacuum in the center of the carbureter, the flexible metal diaphragm will give a little, allowing the piston throttle to come down slightly. This puts the lower ends of the notches into communication with the annular spaces *D* in the walls, so that air may enter at the top, pass through the notches, into the annular spaces, into the mixing chamber, and thence to the cylinders with the mixture. This action is resisted and restricted by the spring *F*.

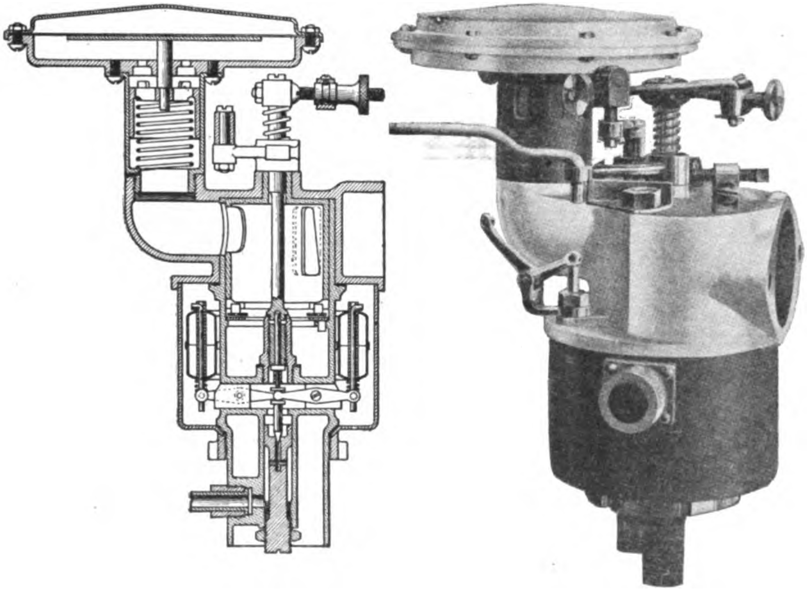


Fig. 32. Section and View of Carbureter Showing Diaphragm.
Chadwick Engineering Works, Pottstown, Pa.

In Fig. 33, *B* is a short piston formed on the lower end of the throttle valve stem *C*. This piston works up and down with the motion of the throttle, its action being opposed by the immobility of the liquid placed in the dashpot *A*. This quality of liquids prevents sudden changes in the fuel supply to the engine, which changes are not desirable—a sudden increase of mixture, for instance, causing racing, while an equally sudden decrease will stall the engine.

To obviate any difficulties which might arise from the use of several different liquids, the gasoline itself is used as the liquid for the dashpot, the by-pass at the right leading it into the dashpot. In all other particulars the carbureter follows standard practice.

An ingenious method adopted by the makers of the G. & A. (short for Grouvelle & Arquembourg) carbureter avoids the principal argument against the auxiliary valve. In this device, shown in Fig. 34, a row of steel balls *A A* are set into as many holes in the ball casing *B*, which communicate with the outer air on the lower side. The balls are free to rise vertically and are of varying sizes from an eighth inch to about three-eighths inch in diameter. As the engine speeds up and draws on the mixture chamber, the lighter and smaller balls are lifted off of their seats, admitting a small amount of air. With greater speed and consequently greater draft, larger and larger sized balls are lifted, admitting more and more air. There are no springs to bother with and no adjustments, the number and size of the balls, fixed by the manufacturer, being equivalent to this. The expense of making the carbureter may be lessened by incorporating in it the inlet pipe. This is frequently done in European cars, as shown by the German carbureter Wildi, Fig. 35. This form uses the piston throttle but the movement is in a vertical direction, contrary to that of all others shown. This is due in part to its being an integral part of the inlet pipe.

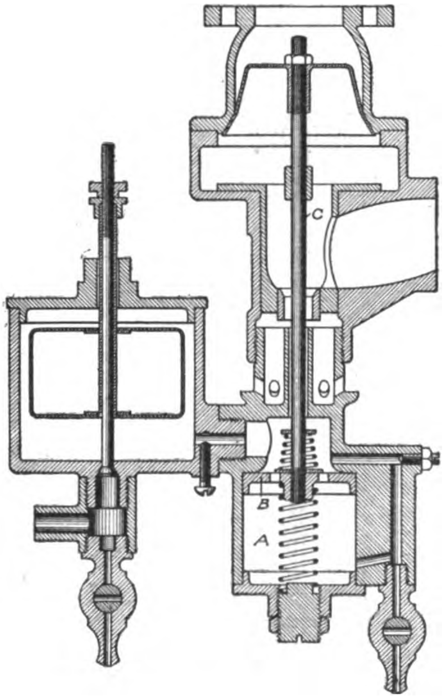


Fig. 33. Dashpot to Regulate Air Supply.

This throttle valve *A* is located on the lower end of the throttle stem *B*, to which is connected the operating levers. The piston throttle

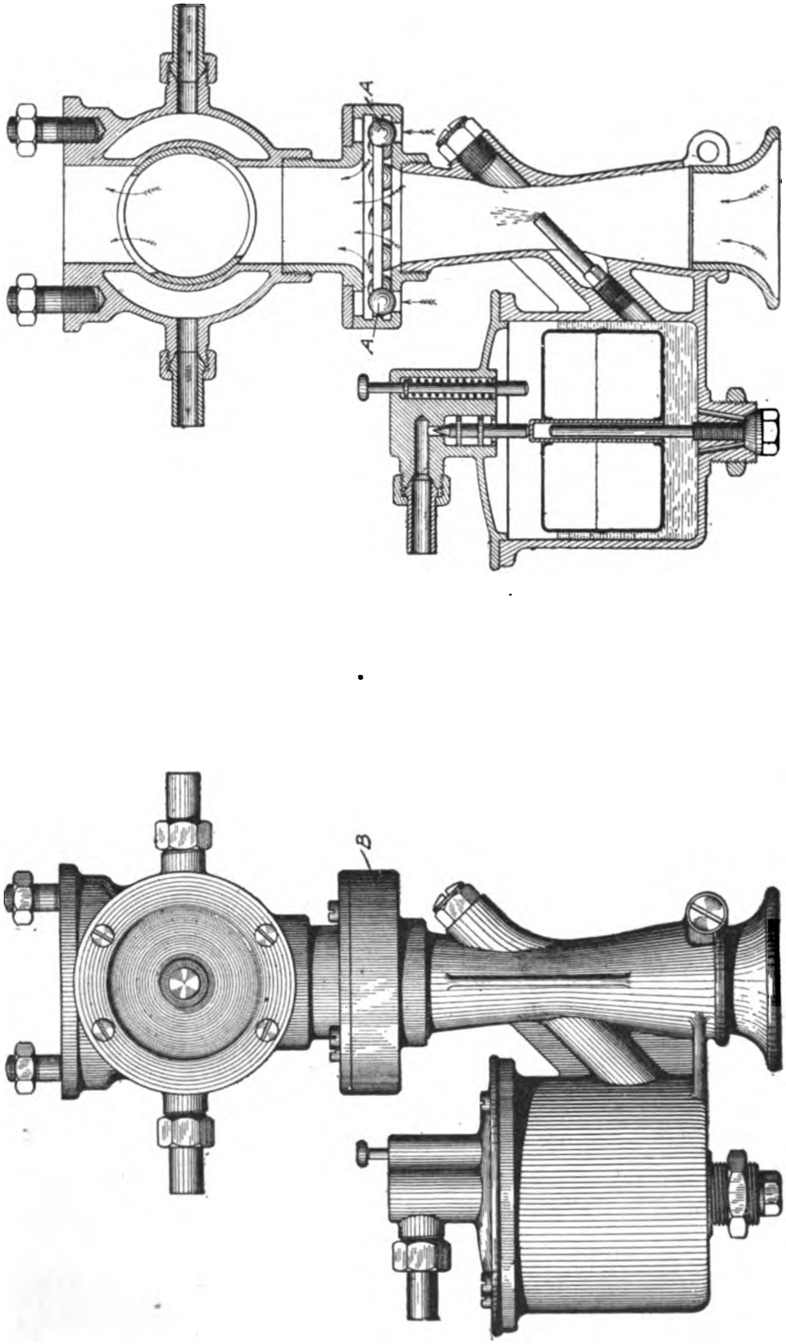


Fig. 34. Elevation and Section of Original Venturi Tube Carbureter.
Grouvelle et Arquembourg, Paris.

A has a row of large holes near the top, through which the mixture passes when the throttle is raised sufficiently to permit this. A still further upward movement uncovers additional air holes through the exterior casing *C* of the carbureter. The remaining actions of the device either are self-evident or follow standard lines. The heating of the gasoline previous to vaporization by means of the circulation of the exhaust gases around the fuel chamber at the bottom, will be noticed.

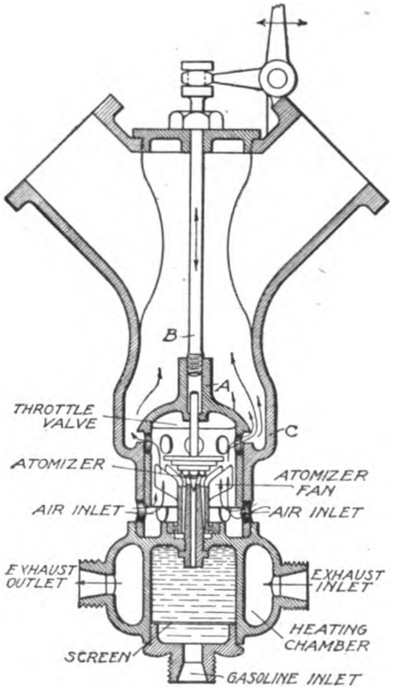
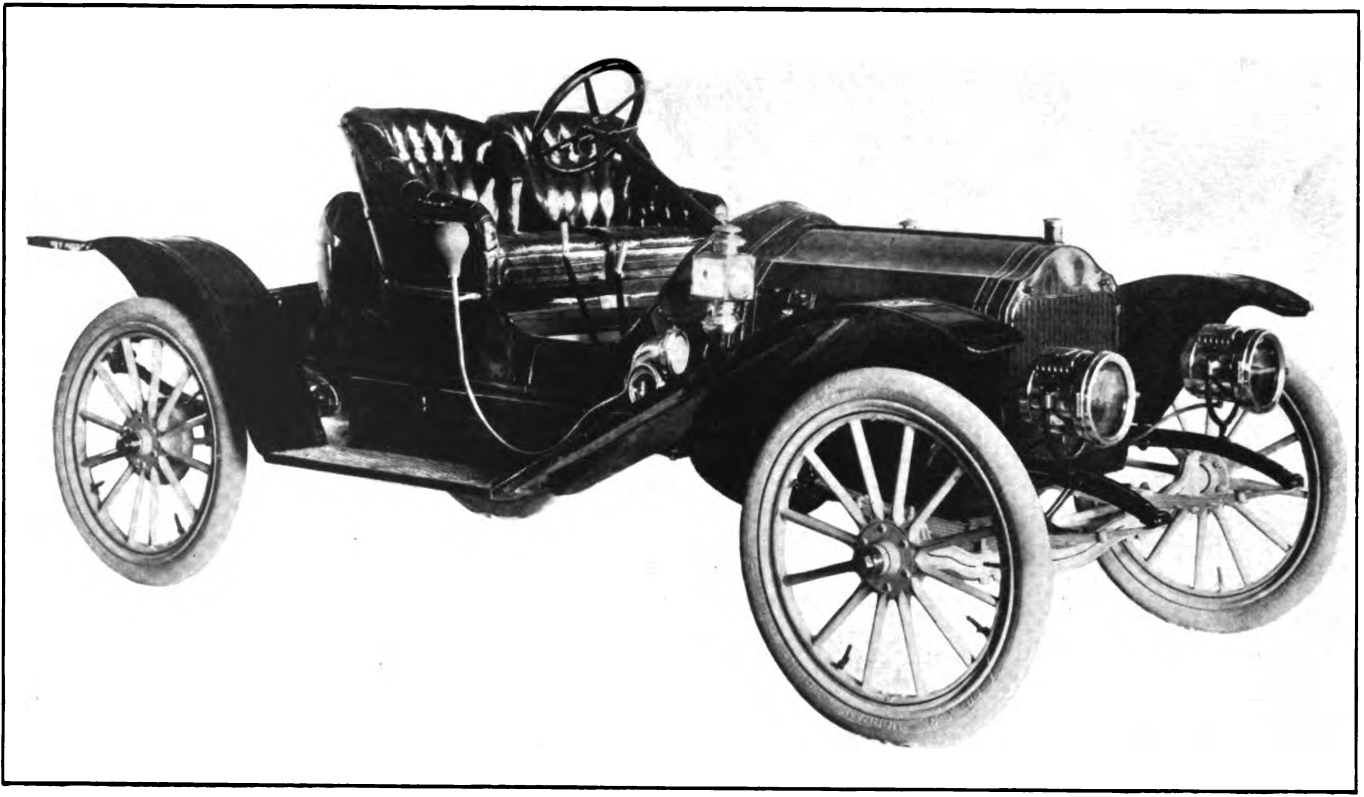


Fig. 35. Wildi (German) Carbureter.

Of course, like every other part of the action of a carbureter, the spraying action and the shape or size of the chamber in which it takes place, have been the subject of much debate. Originally, the chamber took any convenient shape and varied all the way from a perfectly plain cylindrical shape to an equally perfect square, with all of the possible variations in between. About two years ago, however, scientists began to look into the vaporizing and equally important measuring action of carbureters, with the result that a new shape came into use, which was based upon a scientific principle.

This is the principle of the Venturi meter used for measuring the flow of water, and from its use, the tube, or chamber, having this shape has come to be known as a *Venturi tube.* In shape, this consists of two cone-shaped tubes diverging in opposite directions from a common point, which in the water meter is the *point of measurement* and in the carbureter is the *point of location* of the spray nozzle. The principle is that if these two frustums of cones are of the proper shape, *i. e.*, include the proper angle, and are correctly set with relation to one another, the flow of air and gas will be in correct proportion to each other at



FLANDERS "TWENTY" TWO-PASSENGER ROADSTER
The E. M. F. Co., Detroit, Mich

all speeds, assuming first that the air enters at the bottom of the tube having the greater angle.

Venturi Tube Type. As bearing out the principle of this type of vaporizing chamber, it might be said that the majority of carbureters in use today have incorporated it in one form or another, as seen in Fig. 36, Fig. 39, Fig. 41, Fig. 42, and Fig. 45. Many make the upper tube conical for a very short distance, beyond which it assumes a cylindrical form. In the true Venturi shape, the usual angle at the bottom is 30 degrees, while that at the top is 5 degrees. In water meters the contracted area is made one-ninth that of the pipe. This same relation, although not exact, holds in the case of the carbureter. Since the area varies as the square of the diameter, this is equivalent to saying that the diameter of the contracted pipe should be one-third that of the full-sized pipe.

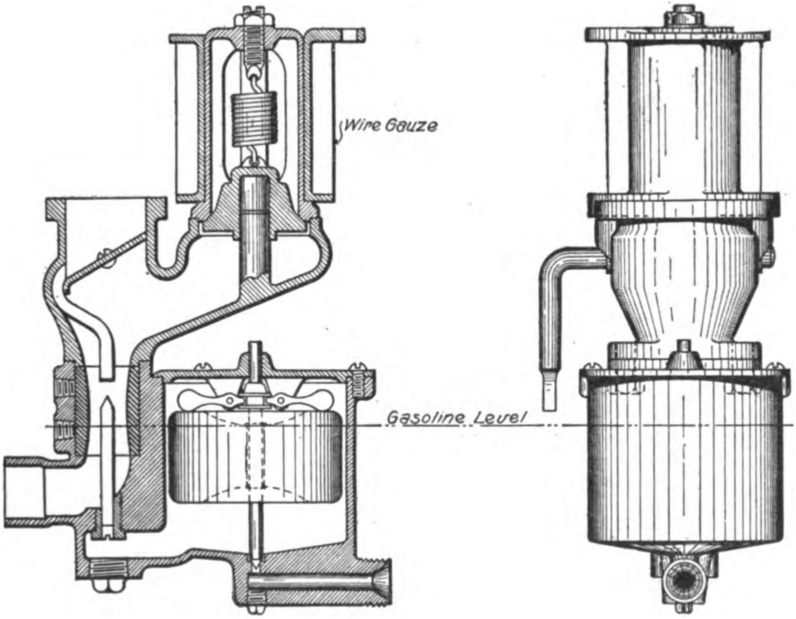


Fig. 36. Oakland Carbureter.

Examples from Up-to-Date Practice. As having much bearing upon the subject and being more to the point than random theorizing, look at some examples of modern carbureter practice as shown in the section of the De Dion carbureter, Fig. 37 and Fig. 38. These illustrations show a number of interesting small points, close attention to which have made the French the foremost automobile constructors.

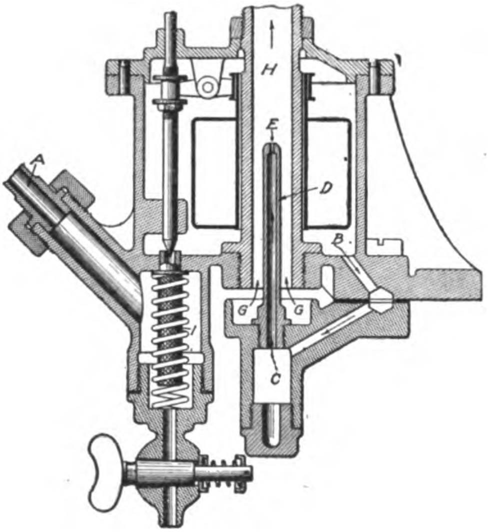


Fig. 37. De Dion Carbureter Showing Strainer and Float Chamber.

Of these two views, Fig. 37 shows the carbureter, while Fig. 38 shows the throttle chamber located higher up in the inlet pipe, and very close to the cylinders. In Fig. 37, the gasoline enters through the pipe *A*, passes through the gauze strainer *I*, through the needle valve into the float chamber, thence, through *B* into the pool *C*. From this a vertical pipe *D* rises to the spray nozzle *E*. Air enters at the base through the holes *G*, passing upward around the standpipe *D*, vaporizing the liquid at the top of the latter, and passing on through the pipe *H* to the engine. Before it can do this, however, it must pass through the throttle, shown in Fig. 38. In this, *H* is the mixture pipe as before, this reaching a throttle valve *J* of the piston type, in the walls of the open end of which are holes *K* through which the mixture enters. When withdrawn sufficiently to the left, the end of the piston clears the edge of the mixture pipe, so that the mixture may then pass directly into it instead of passing through the holes. *L* is the connection to the cylinders through which all gas mixture ultimately passes.

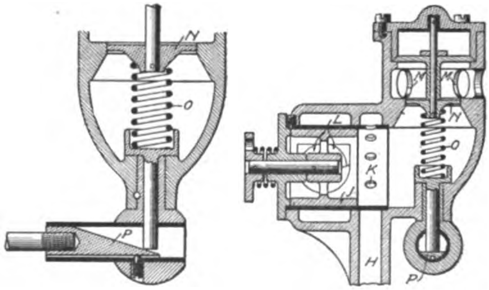


Fig. 38. Details of De Dion Throttle and Spring Tension Adjuster.

In this chamber more air is added. This enters by the ports *M*, and through the valve *N*. The action of the latter is controlled by the spring *O*, which may be adjusted to any desired tension by means of the movable slide *P*. Since this has a tapered end, moving it in raises the stem, compresses the spring, and renders the auxiliary air valve more difficult to open. Consequently less air may enter. Drawing the wedge-shaped end outward has just the opposite effect.

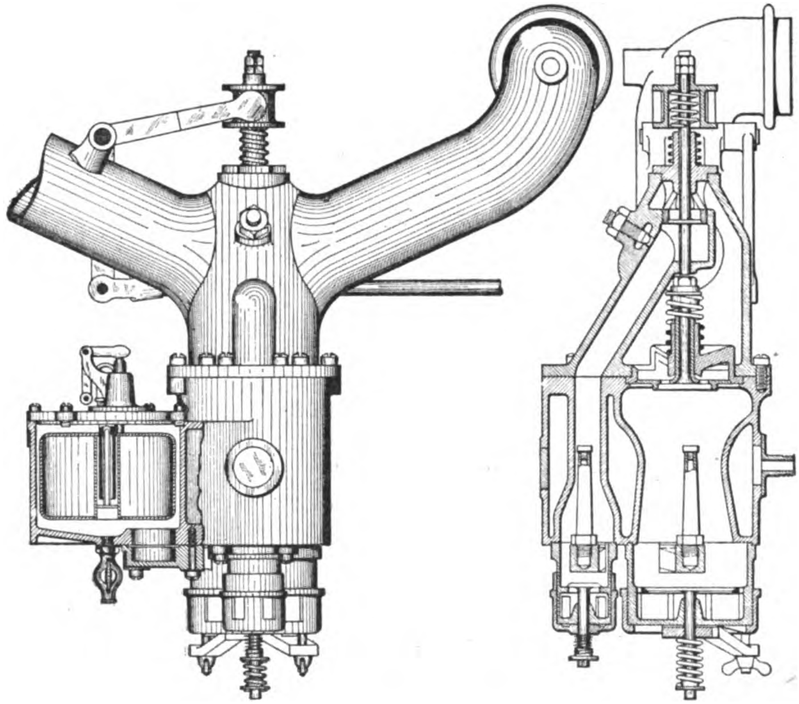


Fig. 39. Stearn's Two-Jet Carbureter.

On the other hand, this country may lay claim to much ingenuity in working out desired ends. Thus, the carbureter in Fig. 40, a Detroit product, shows one attempt to perfect the vaporizing action of the air passing over the liquid fuel. This is done by making the passages through which the fuel passes upward, into a series of radial chambers, large in number and each one small in size. Air enters these from below and through the large ratio of air surface to fuel surface, the vaporizing effect is very good.

Gasoline enters at *A*, passes up into the float chamber *B*, thence through the passage *C*, into the standpipe *E*. Air enters at *G* rising around the standpipe and vaporizing the gasoline spray at the chamber *H*, above the spray nozzle *F*. Additional air enters at *I* passing through a series of radial vanes to the common center, the chamber *H*. From there the carbureted air passes through the pipe *K* to the cylinders. *L* is the adjustment for the needle valve *F*.

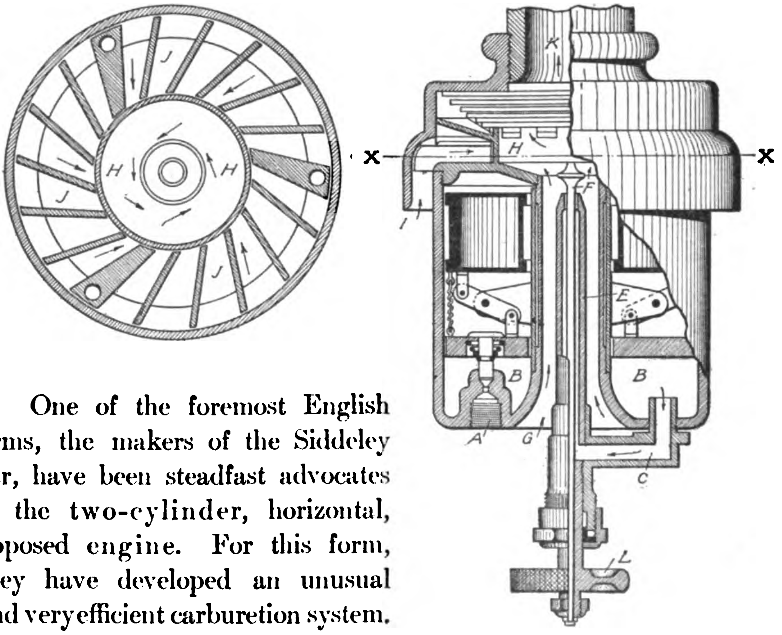


Fig. 40. Watts—Detroit Carbureter. Left-hand Figure—Section Through *XX*.

One of the foremost English firms, the makers of the Siddeley car, have been steadfast advocates of the two-cylinder, horizontal, opposed engine. For this form, they have developed an unusual and very efficient carburetion system. This, as shown by Fig. 43 and Fig. 44, differs from the ordinary case in having a peculiarly shaped auxiliary air valve, and in the method of operating this and the vertical piston throttle valve.

To explain the operation with clarity, Fig. 43 and Fig. 44 must be considered together, as the latter is but the end of the vaporization system, while the former is the starting point of it. Gasoline from the tank enters at *A*, passes through the usual float chamber *B* into the standpipe *C*. Air enters at *D*, vaporizing the gasoline in the chamber *E*. The upper end of this, Fig. 44, tapers down to a small point, while the additional air enters it from above through the flat-seated valve *G*. The two are mixed in the chamber *F*, and thence pass through the throttle valve. This consists of two parts, the outer, *H*, being a *rotary* piston, operated for normal running by the lever *J*. Within this piston, however, is a sliding piston throttle *L*, which is operated by the additional lever *K*. The two in combination allow many and varied combinations of rich and lean mixtures to enter the inlet pipe *II*, and through it, to reach the cylinders of the engine.

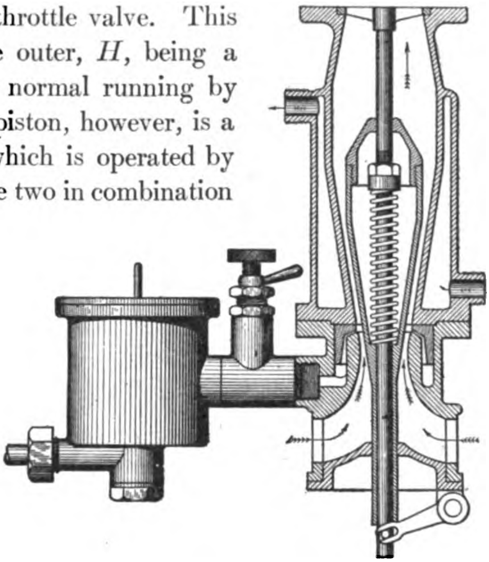


Fig. 41. Decauville (French) Carbureter Using Tapered Mixing Chamber.

Not to be outdone by other nations are the Germans and the Swiss. As an example of the work of the latter, none would be more appropriate than that of the great constructor, Saurer, of Arbon, the designer of the Saurer and Safir trucks and pleasure cars. His carbureter design, known as the *Economy*, is shown in Fig. 46. The peculiarity lies in the two standpipes *A* and *B*, one of which may be cut off by the action of the flap throttle valve *C*. This latter is operated by the demands of the motor, consequently when the need for fuel is greatest, it stands vertically so that both fuel standpipes or nozzles are supplying fuel.

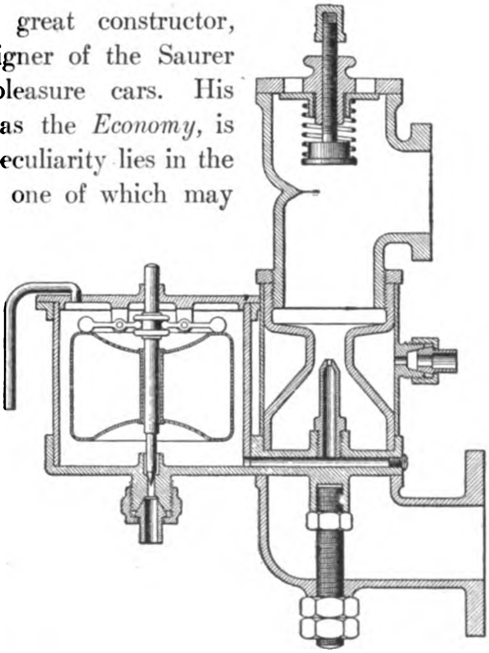


Fig. 42. Argyll (Scotch) Carbureter with Liberal Air Passages.

As shown in the figure, but one standpipe *A* is working, but as soon as the motor's demands increase, the suction will draw the flap throttle valve *C* out of its inclined position, and then standpipe *B* will begin to furnish gasoline to the vaporizing chamber in addition to standpipe *A*. When the demand is greatest, both nozzles are supplying the full amount of gasoline, and the flap is standing vertically. Its action is partially restricted by a wedge attached to the throttle valve stem.

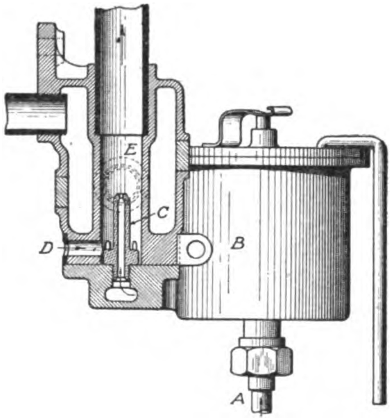


Fig. 43 Section Through Siddeley (English) Carbureter.

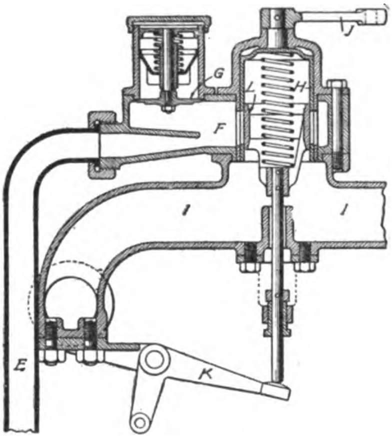


Fig. 44. Siddeley Mixing Chamber and Inlet Pipe.

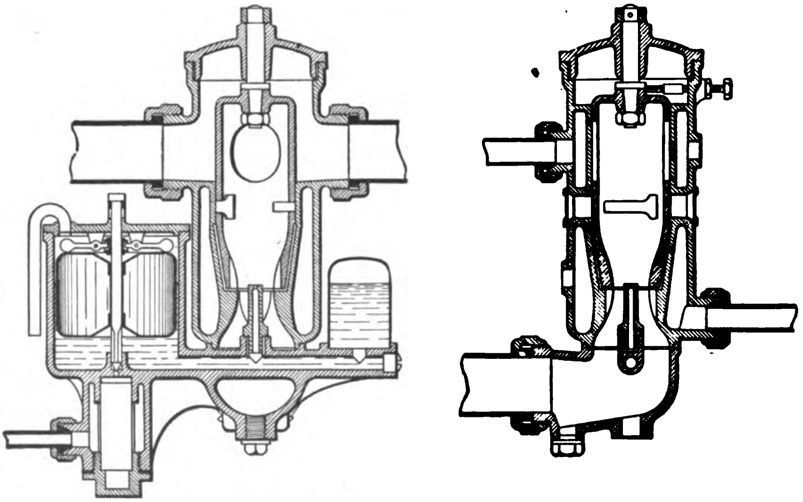


Fig. 45. Up-to-Date Daimler Carbureter, Shown in Two Sections.
Daimler Actiengesellschaft, Unterturkheim, Germany.

No better type of German practice than the Benz could be selected. The carbureter from this car is shown in Fig. 47, in which the early connections of Maybach may be clearly traced. This is apparent in the rotary piston throttle, the shape and action of the float, the hand regulation of the fuel inlet opening, and many other small details.

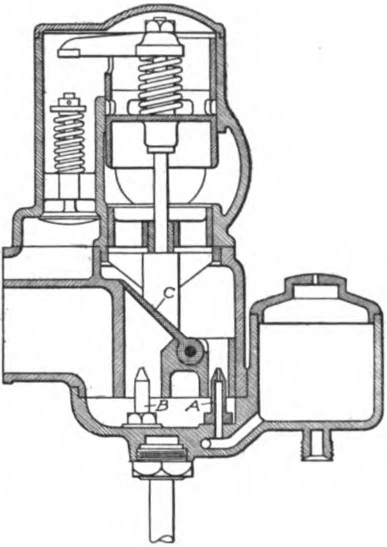


Fig. 46. Saurer (Swiss) Carbureter with Two Standpipes.

Probably the latest idea in vaporization is that brought out within the past half year as a feature of the Zenith (French) carbureter, Fig. 48. This is but a modification, in a way, of the Venturi plan, for the latter shape is actually used for the vaporizing chamber. The new idea consists in leading into this mixing chamber, not one but two tubes. Of these, one is the ordinary spray nozzle and does not differ from that used on hundreds of other devices. The second, however, is very different, and while

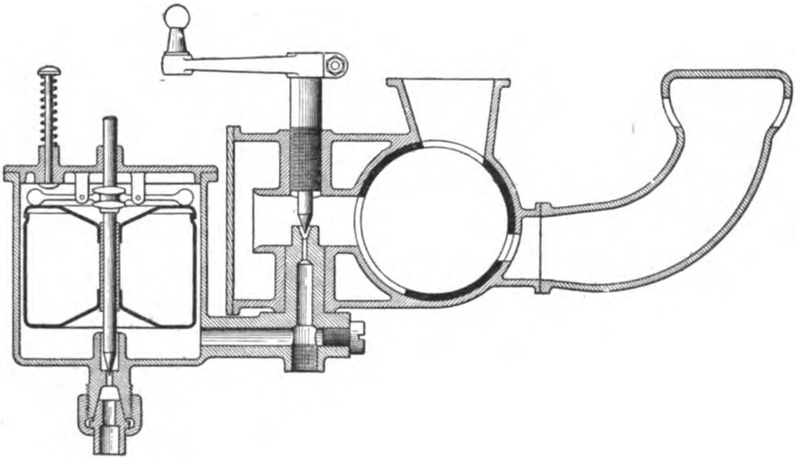


Fig. 47. Benz Carbureter Showing Hand Regulator for Needle Valve.

leading into the same mixing chamber, does so through the medium of a secondary chamber or standpipe, to which the suction of the engine has access. If this suction is strong, more gasoline is drawn into the secondary chamber, from which it may enter the spraying zone.

The ordinary nozzle is of an exact size, and consequently can pass only a certain amount of fuel, always at the same speed. With the additional nozzle, this does not hold, and being of large diameter (comparatively), the flow through it depends wholly upon the engine suction, which varies at all speeds, often at the same speed upon different occasions. Stearns (American) also uses two nozzles.

In starting a car or any engine, whether located in a car or not, everything should be inspected so as to know if all is right before attempting a start. With the novice this is somewhat of a task, but to the old hand it is so much of a routine task that he does it unconsciously.

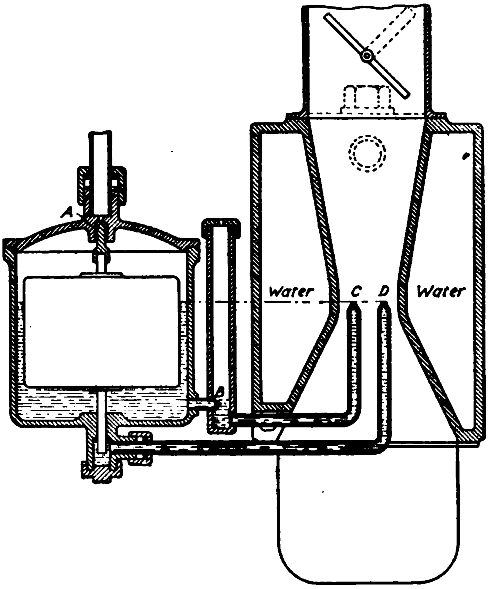


Fig. 48. Zenith (French) Carbureter.

Troubles. *Engine Should Start on the First Turn.* If all conditions are right, the carbureter is primed and the engine will start on the first turn of the crank. If it does not do so there is a source of trouble which must be remedied first and it is useless to continue cranking. This may lie in the fuel system itself, but exterior to the vaporizer, or it may be in the ignition apparatus. It is well in a case of this sort to start with the gasoline tank and follow the fuel through each step until it apparently reaches the combustion chamber in the form of a properly proportioned mixture of gasoline and air.

To start with the tank—is there enough fuel in it not only for starting purposes, but enough to allow of making the proposed trip? This is readily ascertained by unscrewing the filler cap and inserting a measuring stick. For the purpose a graduated rule is good, but not necessary; any stick or small branch of a tree will answer, or, lacking all these, a piece of wire can be used. A string tied to a very small weight will also do.

Having verified the presence of fuel, the next question is: Does it reach the vaporizer as it should? Nearly all carbureters have a drain cock at the lowest point. Open this and if fuel flows out in a steady stream you may be sure that the pipe from the tank up to this point is not clogged. In case the carbureter does not have a drain cock, the same result can be effected by holding the primer down for a long time when the gasoline will overflow through the air inlet.

In either case, if there is no sign of gasoline when the tank contains plenty, it is apparent that the feed pipe is clogged and the method of procedure is as follows: Shut off the cock below the tank so that none of the previous liquid can escape, then drain off the carbureter and pipe into a handy pail. Next open the union below the cock in the feed line and the one at the other end of the same pipe. At both places look for obstruction. Then clean the pipe out thoroughly, using flowing water, a piece of wire, or other means which are available at the time.

Gasoline Strainer a Source of Trouble. Finding nothing here, it will be necessary to search. Look in the strainer of the carbureter to make sure that the flow is not stopped there by the accumulation of dirt and grit, filtered out of the fuel. The strainer should be cleaned often, but like many other dirty jobs is postponed from time to time.

Should this source of trouble prove "not guilty" the carbureter itself becomes an object of suspicion. Is the float jammed down upon its seat or are there obstructions which prevent the flow of fluid? Is the float punctured, or has one of the soldered joints, if a metal one, opened, or is it fuel-soaked, if cork?

A Bent Needle Valve Stem. To attend to this sort of trouble, disconnect the priming arrangement, take the cover off of the float chamber (it usually is screwed on with a right-hand thread), and take the float out. An examination of the float, Fig. 49, will disclose whether it is at fault in any of the above-mentioned ways, all of which are comparatively easy to fix. If the float was jammed down, perhaps by priming, the act of taking it out will cure that, provided that the stem of the float is not bent and the needle valve or its seat not injured. If the seat is scored it should be ground in just like any other valve, using oil and fine emery. A fuel-soaked cork should be thrown away if another is at hand to replace it, but if not, the cork float should be moved in its position on the stem so that it sets higher in the liquid. In other words, move the cork a sufficient amount to compensate for its loss of buoyancy.

In the case of a punctured float of metal or loose solder, the only real remedy is to resolder in either case. It usually happens that a soldering outfit is not available out on the road and some form of makeshift will be necessary to allow of reaching a place where a soldering iron may be had. If the puncture is on the bottom, it is sometimes possible to accomplish this by inverting the float so that the hole comes at the top where the gasoline seldom reaches. If the flow be reduced to make sure of this, it is possible to reach a place where a soldering iron may be procured.

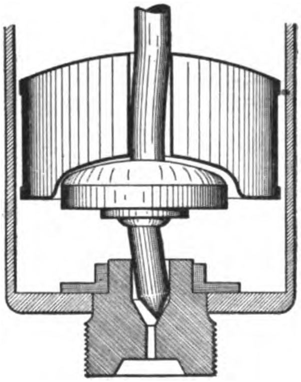


Fig. 49. Bent Needle Valve.

A remedy which might be tried in an extreme case of this sort is to fill the float to make it heavy, so that it will have a tendency to sink. Then take a small diameter spring, cut off a short piece of it and place it in the float chamber so that it opposes the sinking action of the now-heavy float. By carefully determining the length, and thus the strength of this spring, the same action is obtained as would be had if the float were working all right. Of course, if the entrance of the liquid fuel is such that the sinking of the heavy float tends to close rather than open the gasoline inlet, the spring would have to be on the bottom and fairly strong so as to oppose the action of gravity. But if the float works downward to open the gasoline passage, the spring will be at the bottom and very weak, simply being there to prevent an excessive flow.

Throttle Loose on Shaft. Now the carbureter trouble has been reduced to a minimum. The remaining troubles might be centered in a clogged spraying nozzle. But this nozzle is readily removed, and with it the trouble, if that be the offending member. If the spray is proven *O. K.*, the throttle is ready for attention. If of the butterfly type it may have become loose on its shaft, or what is the same thing, the operating lever may be loose. In either case the shape and weight are such that it would swing into such a position as to cut off the entrance of gas to the inlet pipe and thus to the cylinder. If the throttle is of the circular sliding or piston form it may not be connected to the throttle rod, but is stuck in such a position as to prevent the passage of gas. This sometimes happens when running, and then, apparently, closing the throttle does not stop the engine. The writer had this happen to him once at a time when it was absolutely necessary to stop. The only way that trouble was averted was by the instantaneous closing off of the switch and the hasty application of the brakes.

The last hope of finding trouble in the carbureter system rests with the inlet pipe. If the source of the trouble is not found elsewhere, take this off in search of misplaced waste or similar substances. The size of the pipe is such that anything in it large enough to cause trouble may be instantly seen and removed. The only exception to this is a small hole in the inlet pipe casting, which will not only cause trouble with the mixture at all times, but is also very hard to find, particularly if it happens to be of very small diameter, caused by a single grain of sand, for instance.

The valve or cock controlling the flow of liquid from the tank should be examined frequently and care be taken to keep it in good shape. It must act hard and must be tight, so that no gasoline flows when it is supposed to be shut off. The reason for having it act hard is to prevent it jiggling shut during a long run which results in the engine slowing down and stopping without any apparent reason until the tank is looked at when the supply is found to be shut off. A method of fixing it—which, in general, is not to be recommended—is to open the cock and then hammer the handle so as to jam it tight against the seat, but in the open position. This makeshift will answer until a place is reached where the taper seat can be reground or tightened in place, if that is what it needs. In case the driver does not wish to do this, and the cock is of the two-way type, open when the handle is parallel to the axis of the pipe, it may be tied in the open position by passing a cord around the cock and pipe.

STARTING DEVICES

As far as starting is concerned, motors have been turned over by hand ever since the industry sprang into being about 1885. But as sizes grew larger and larger while the number of cylinders multiplied, this became more and more of a task. With progress in mechanical construction came progress along lines of theory, such as increased power due to greater compression. This worked out nicely but made the resulting engines even more difficult to crank over. Finally the stage was reached on racing cars, with engines of immense size and compressions of 110 pounds and upwards, which one man could not turn over regardless of his strength. So at such times and places as the Vanderbilt Cup Races of 1907 and 1908, it was not an uncommon sight to see five or six men on the end of a six-foot bar turning a big racing engine over to start it.

This condition did not obtain in the case of ordinary engines, but even these became so large that starting was a strenuous, not to say dangerous, task. Under these conditions, a call arose for self-starting devices, which, while it was stilled by the advent of engines with more cylinders giving the same power with a smaller bore and by the more recent development of much lower-powered engines, nevertheless still exists and with surprising though latent strength.

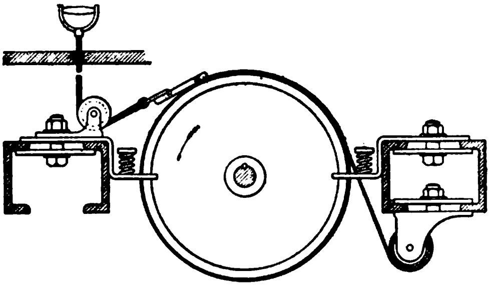


Fig. 50. Strap Starting Device.

Speaking broadly there are three classes of starting devices worthy of mention, viz, the *mechanical* or *spring actuated* devices; the *compressed fluid* devices; and the *electrical* starters.

Mechanical Systems. In the first class properly belongs any mechanical contrivance by the use of which the driver of the car does not have to "wind up" the motor by means of a rotating lever directly attached to the engine, and, therefore, liable to a "back kick," which is the real objection to the cranking of the engine. This class includes such devices as the coil spring, wound up by the running of the engine after having been once started by hand. This is wound up tight and then the engine automatically cuts itself out, leaving the spring tense. To use the starter, the spring tension is suddenly relieved by a suitable device and the tendency of the spring to unwind results in a rotary motion which turns the engine over.

In this class also belong that type of starters in which a strap is pulled upwards or sideways, this motion rotating the flywheel or other suitable drum. A spring returns the strap to place, so that it may be used over and over with no appreciable interval. In case the engine backfires or tries to rotate backwards, the strap simply slips on the drum or is pulled out of the operator's hand, with no attendant danger. Fig. 50 shows a commercial form of this type in which the strap is plainly seen. On the right is the drum upon which the strap is wound and held by means of a spring. The band or strap is normally held away from the drum by the two clips and springs, one on each side, but, when force is exerted upon it to turn the engine over, these allow the band to take hold. In this way there are no friction losses from the dragging of the band when it is not in use. The angle of contact is very large, being nearly 450 degrees, so that a small coefficient of friction (such as this device would have) is sufficient to do the work.

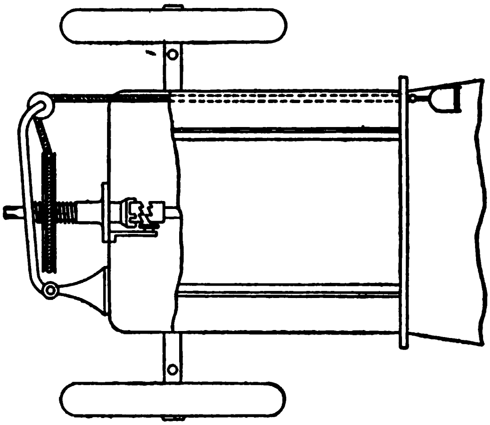


Fig. 51 Mallins (English) Mechanical Starter.

This principle is utilized in another starter, which has a side lever in place of the handle, the remainder of the parts being the same. Another one of the mechanical starters uses the side lever, but for the actuating means has a modification of the worm and gear. A deep spiral groove *G*, Fig. 51, is turned in the prolongation of the shaft and a pair of dogs set into this. The latter, Fig. 51 and Fig. 52, are constrained to move in a straight line, so that only the shaft rotates. By operating the hand lever the other lever carrying the dogs is moved, and through the medium of the spiral groove turns the shaft around, the total motion depending upon the length of the spiral and the amount of the lever motion. It may, however, be such as to afford three turns of the shaft, which usually are sufficient for starting purposes. A jaw clutch prevents the rotating of the engine from being retroactive, *i. e.*, from working the starting device in the opposite direction.

Very similar to this is the form in which a rack and gear are employed, the latter arranged on the crank shaft with a clutch, and the former contacting with it. Motion of the hand lever draws the rack across the car, thus rotating the shaft, and with it the engine. Still other mechanical starters have been brought out and, in some cases, successfully used, but in the main these follow along the lines of some of the above-described contrivances.

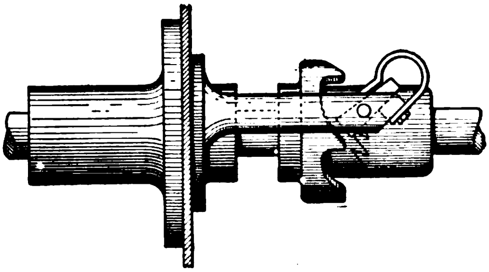


Fig. 52. Detail of Mallins Mechanical Starter.

Compressed Fluid Systems. Owing to the fact that all of the mechanical devices require more or less physical exertion, the difference between them and the ordinary cranking being a linear instead of circular motion, and the elimination of all danger, the use of a fluid pressure system in which there is neither work nor danger is more desirable and deservedly more popular. After cranking over a big motor the notion of pressing a button to start it is particularly attractive.

Nearly all of these use the air, but some employ the exhaust gases. The advantage in so doing lies in the elimination of the compressor and the attendant mechanisms to drive, connect, and disconnect it. This method, besides making for simplicity, saves weight, and the elimination of extra parts allows the driver more peace of mind. All this is said with the proviso that the arrangement works and works at the desired time, without which it is useless. The doubt here expressed is a large item, and has proved the downfall of many an apparently good mechanism.

The system just spoken of may take either one of two forms, viz, the actual exhaust waste gases may be drawn off from the motor, stored in a tank, and used as a source of energy; or the mixture may be taken during the compression stroke, just before ignition, so that the starting fluid is a combustible mixture and differs in the strict definition from carbureted gas only in being under great pressure. This latter is also stored in a tank.

The complaint made against using the exhaust is that the starting gases so weaken and impair the mixture from the carbureter that a considerable number of turns are necessary to start the machine. This, in turn, means a very large gas storage tank, which adds materially to the weight of the car. The exhaust pressure, in a well-designed engine running under normal conditions, seldom exceeds 45 pounds, so that a high pressure may not be obtained from this source.

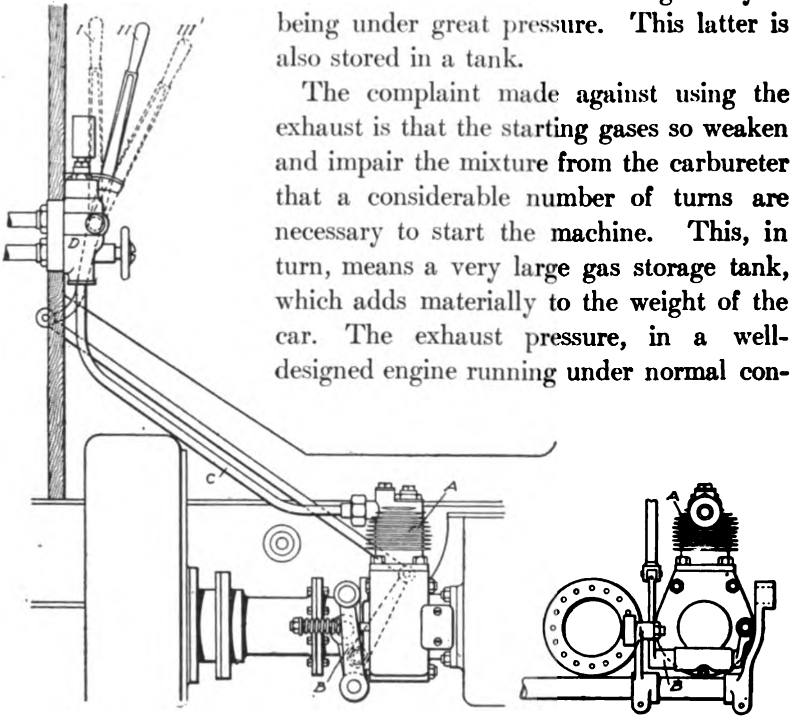


Fig 53. Principal Parts of Saurer Air-Operated Starter.

The method of utilizing the compressed gases has the same detrimental feature, but not in so marked a degree, *i. e.*, that a wide range of pressure is impossible. However, a very high pressure in comparison with the other method is obtainable. The compression usually runs from 70 pounds upward, and it has been known to be as high as 110 pounds, so this would give good, if not maximum, results.

With an outside and independent compressor any desired tank pressure may be obtained, and, as a matter of fact, the majority of these systems do use it higher than any of the figures thus far given. In the Saurer system, 225 pounds is maintained in the reservoir at all times, while the Renault method utilizes 250 pounds. Other pressures are used, all being above 200.

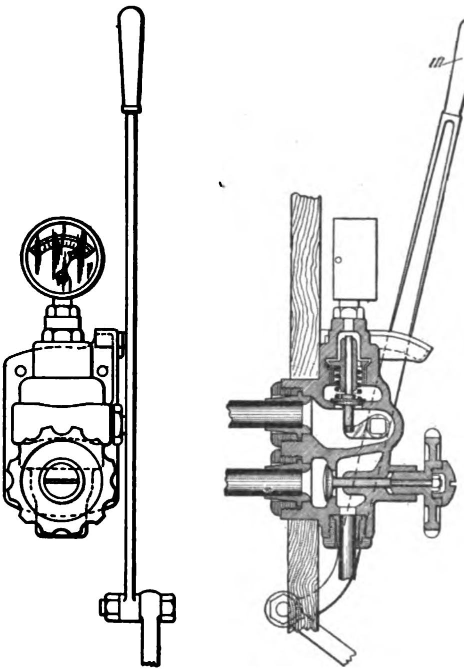


Fig. 54. Dashboard Control of Saurer Starter.

As usually constituted, a fluid-pressure system consists of a compressor as a source of pressure, a storage tank, a distributing valve, and a lever, button, or other operating means. In use, the engine must be started by hand in the first instance. This creates a source of power, whether it be exhaust gas, compressed gas, or air from a compressor driven from the crank shaft or cam shaft.

Saurer. Fig. 53 shows the essentials of a system in which the air-cooled compressor is driven off of the main driving shaft just ahead of the gear case. The hand lever shown on the dashboard, when forward in the position *I*, throws the compressor clutch in, and it then charges the storage tank. The valve to the latter is set at 225 pounds, and when that pressure is reached the clutch is automatically cut out and the compressor stops working.

A is the air-cooled compressor, which is driven from a forward extension of the transmission shaft, as soon as thrown into engagement by the linkage shown at *B*. This linkage is operated from the dashboard as previously described. The air when compressed, passes through the pipe *C* to the distributor *D* on the dashboard, and thence to a storage tank not shown. The left-hand end is a side view, while at the right is a small detail view taken from the front.

When it is desired to start the car the lever, shown in larger size and more detail in Fig. 54, is pulled backwards as to position III, the compressed air from the tank flows up through the governing valve and thence to the distributor. The latter is situated high up between cylinders 2 and 3, and is driven by miter bevel gears from the crank shaft so as to have the same speed of rotation as the latter. This consists of a revolving sleeve in which are cut ports, one for each cylinder. As the sleeve turns, Fig. 55 (with the crank shaft), these ports register in turn and in the proper firing order, with passages which connect to the individual cylinders. The air under pressure is admitted by the governing valve, on the dash previously spoken of, to the interior of this sleeve, and thence to the proper cylinder.

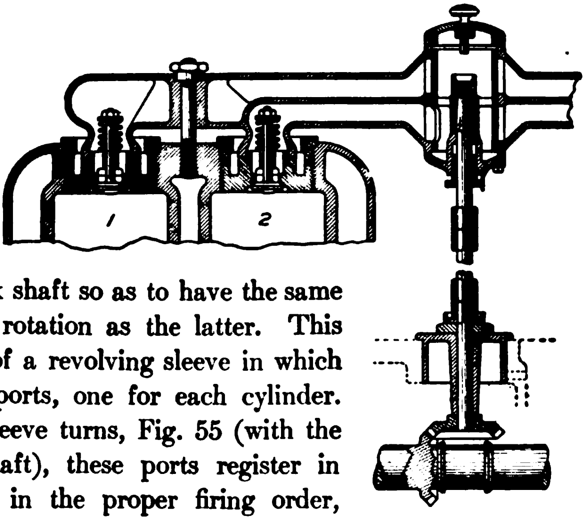


Fig. 55. Distributor Valve Details of Saurer Starter.

As shown in Fig. 55, this is open to cylinder, 2, and in this situation the air will pass into that one and drive the piston down. This must necessarily turn the crank shaft around, and with it the distributing valve, which thus registers with the cylinder next in the firing order, 4, or whatever it may be. From this it is plain that the tank will continue to furnish compressed air to the cylinders, in proper rotation, until all of the supply has been exhausted or the engine has been started and the supply cut off. Another and different view, Fig. 56, shows the dashboard with the control mechanism, the small, air-cooled compressor being in the foreground.

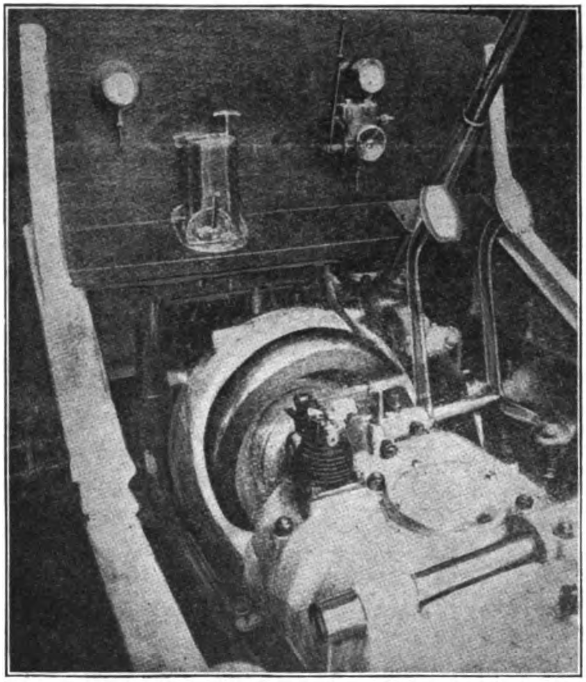


Fig. 56. View of Saurer Starter in Place.

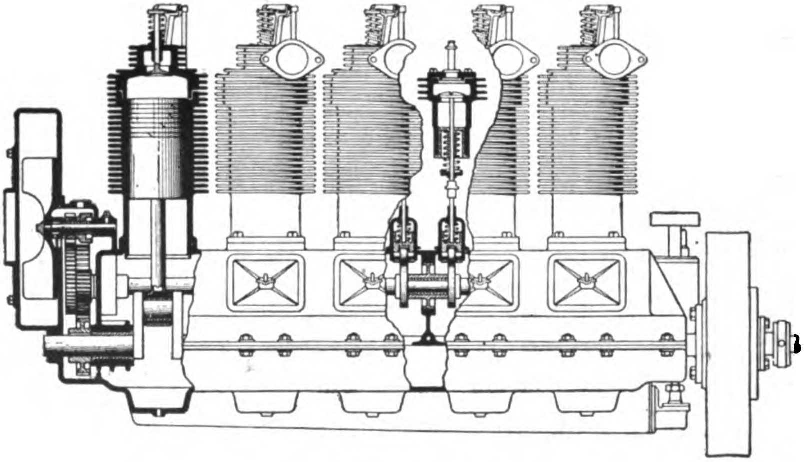


Fig. 57. Rowe Starter Applied to 5-Cylinder Engine.

Rowe. Another starting scheme of much similarity known as the *Rowe self-starter*, is that applied to one specific design of air-cooled car, and shown in Fig. 57 and Fig. 58. As is there shown, a source of compressed air is connected up to the fuel inlet system just beyond the carbureter. Then, to start the engine, the air supply is turned on. This rushes through the carbureter, picks up gasoline, vaporizes it, and thus fills the cylinders with an explosive mixture. Since the production of a spark in any one cylinder is an easy matter, it is plain to be seen how this starter works. The engine, to which this is fitted, starts readily for the simple reason that it has an odd number of cylinders, five, and thus has one cylinder always in the firing position, and ready to be started.

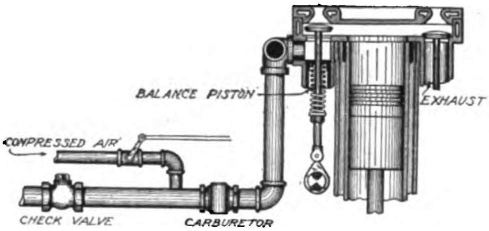


Fig. 58. Section of Rowe Starter.

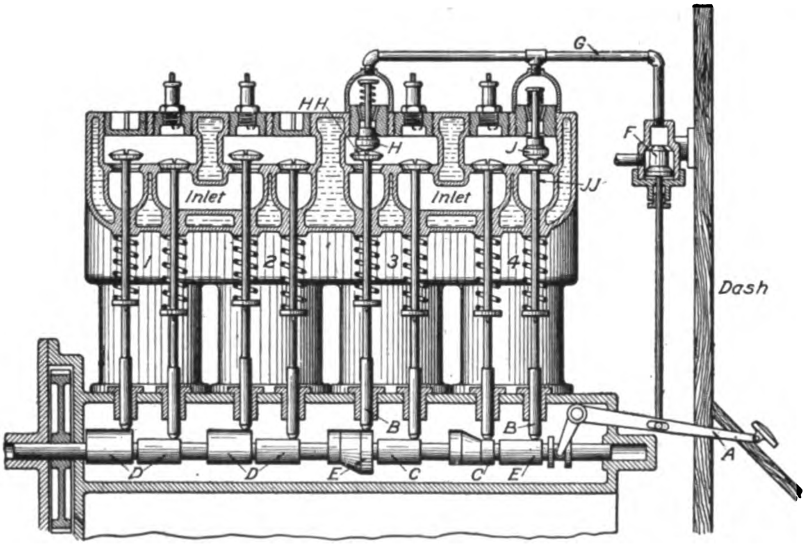


Fig. 59. English Starter Using Two Cylinders as Air-Compressors.

English Devices. In Fig. 59 are shown the essential parts of an English starting device which converts two of the engine cylinders into air compressors by shifting the cam shaft longitudinally. This is done by the foot pedal *A*, which moves different cams, or rather, a different part of the cams *C* and *E* under the push rod. The altered shape of the new cams causes the function of the cylinders to be changed into air compressors, which then act to store air under pressure in a tank. To start, the action is reversed and the air flows into the cylinders, moving them downward, and thus starting the engine.

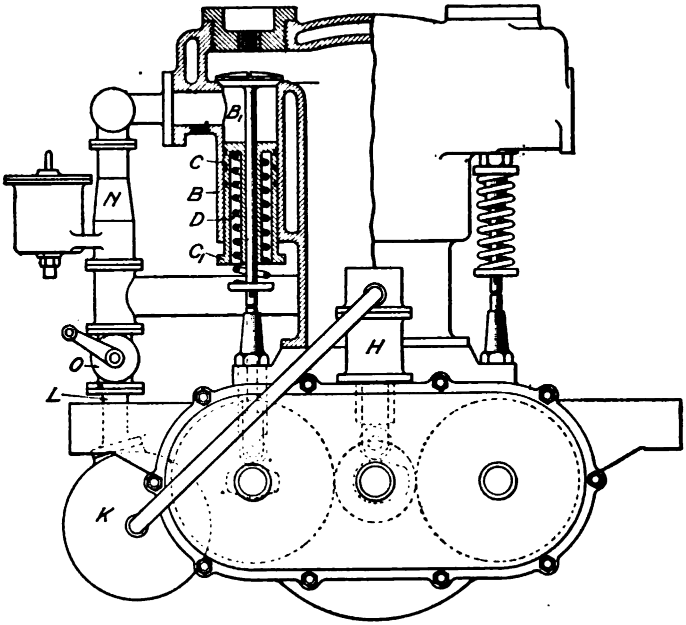


Fig. 60. Gore (English) Fluid-Pressure Starting Device.

An English starter, that of Gore, Fig. 60, sends compressed air through the carbureter, thus filling the cylinders with an explosive mixture which is readily ignited. *H* is the compressor driven from the crank shaft by the cam shown dotted. The compressed air is piped to the tank *K*, which communicates with the lower end of the inlet pipe at *L*. *O* is the throttle which puts the tank into action. This being opened, the compressed air rushes through the carbureter *N*, picking up some gasoline, and vaporizing it. Passing on through the inlet pipe, the pressure is sufficient to open the inlet

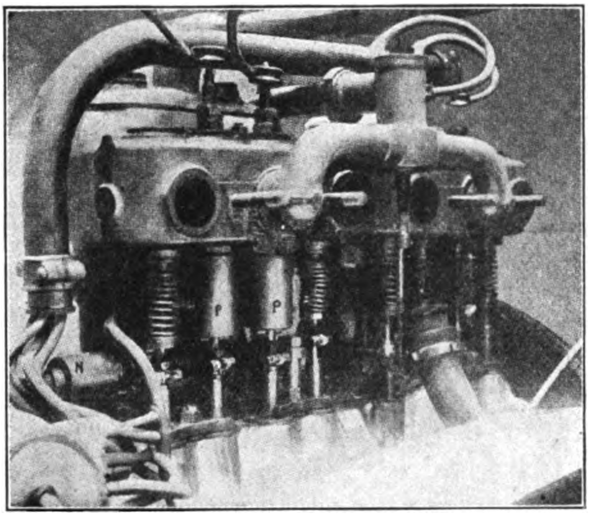


Fig. 61. Doué (French) Starter in Place on the Engine.

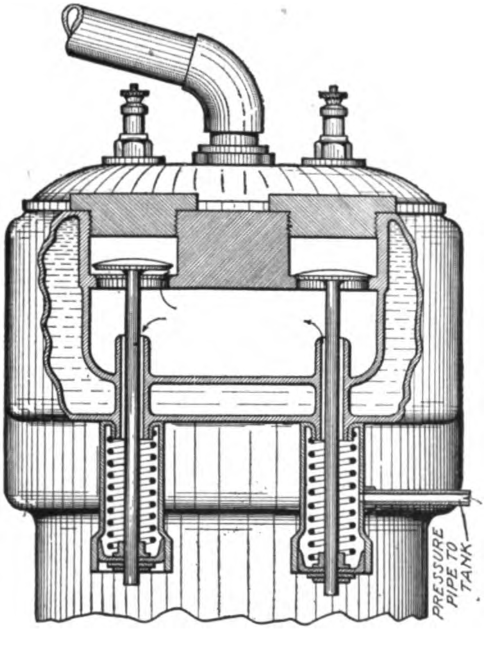


Fig. 62. Doué Pressure Admission to Valves.

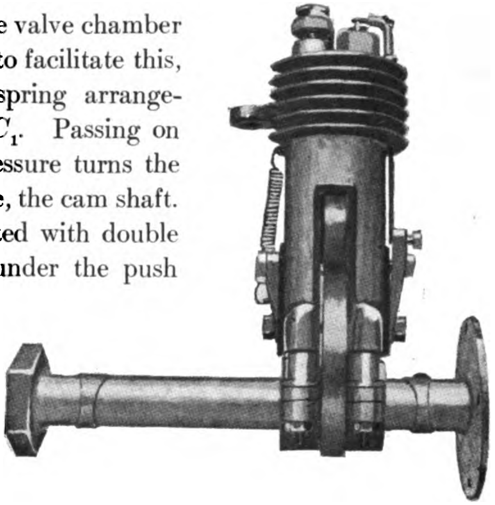


Fig. 63. Detail of Doué Air-Compressor.

valve, the lower part of the valve chamber B being specially formed to facilitate this, as well as the special spring arrangement, shown at $C\ B\ D\ C_1$. Passing on into the cylinders, the pressure turns the engine over, and, of course, the cam shaft. The inlet cam shaft is fitted with double cams, which are shifted under the push rod at starting time. These open the inlet valve twice as often as it would be opened otherwise, and thus permit the air pressure twice as many entrances to the cylinder as would ordinarily be the case with carbureted gas. The doubling of the entrances is a very necessary provision as after the tank is once opened, the pressure falls rapidly. All this gas being carbureted gas and not atmospheric air, as soon as a hot spark is obtained, the engine may be considered as started, and the tank shut off.

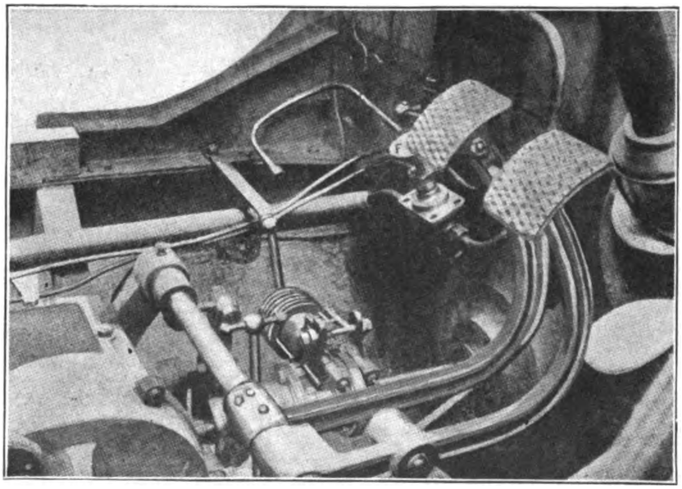


Fig. 64. Air-Compressor of the Doué Starter in Place.

Although to Saurer has been ascribed the most successful of self-starters and European constructors pay license fees to him as the holder of all starter patents, that fact does not entirely eliminate originality in the matter of details. This is to be plainly discerned in the Doué, a French starting device, as illustrated in Fig. 61, Fig. 62, Fig. 63, and Fig. 64, and that of the Renault, Fig. 65. All of these depend upon a source of compressed gas, which is distributed to the proper cylinders by a timing device.

Renault. Renault's starter operates as follows: At the front end of the engine is placed a small air-cooled compressor *H* which is connected by means of the pipe *J* to the distributor *N* on the dashboard, and through that and the pipe *L* to the storage tank *R*. From the valve *N* on the dash another pipe *K* leads to the actual distributor *C*, which is driven from the cam shaft *A* by the inclined shaft *B*. This puts the air under pressure in the pipe *K* into communication with the cylinder in which the piston is in the proper position for starting, the cylinders and distributor being connected by the two-branched pipe *E*. When running, the tank is filled, and then the compressor is thrown out, as described later. Now, with a tank *R* full of highly compressed air, if it is desired to start, the handle *D* is pulled upward, which opens an internal port, and allows the air to pass through to the pipe *K*, which, as mentioned before, leads to the distributor and cylinders.

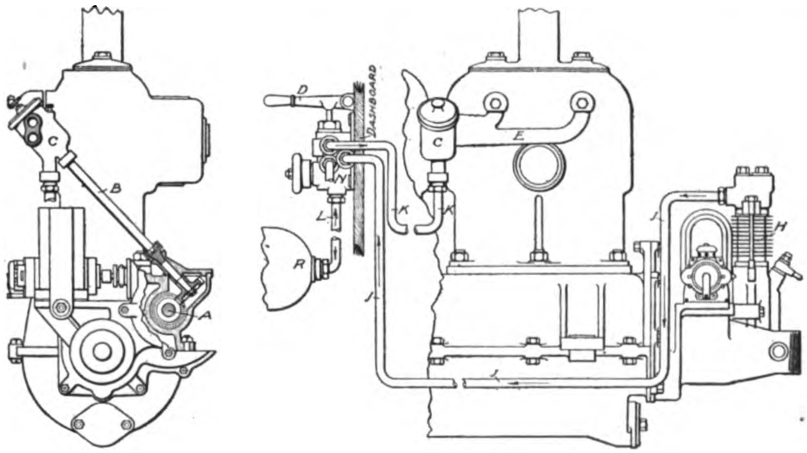


Fig. 65. Component Parts of Renault (French) Self-Starter.

A prominent feature in the Renault system may be mentioned briefly. This is essentially the same as the one just described but the control of the compressor differs in that the air suction valve has a flexible diaphragm, Fig. 66, which is in contact with the tank, or, rather, to which the compressed air has access. As the pressure rises this distends until, at the predetermined maximum, it holds the air inlet open, thus preventing compression and consuming no power. Of course, as the pressure falls off from leakage or the use of air, the diaphragm changes its position to correspond, until at a certain fixed minimum pressure the suction valve will be allowed to close on the compression stroke, and thus the tank will be automatically replenished.

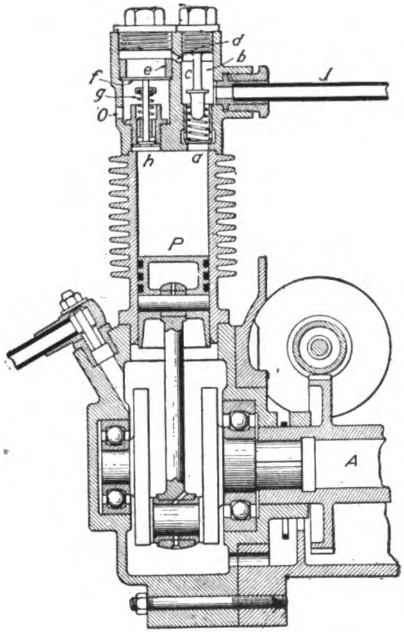


Fig. 66. Renault Air-Compressor.

In the figure, *A* is the driving shaft, *P* the piston, *J* the supply pipe to the pressure tank, *h* the inlet valve, and *a* the outlet or discharge valve. Air enters the small hole *O*, passes through the inlet valve, the suction within opening it against the spring *g*. It is then compressed, passes out through discharge valve *a* and the pipe *J*. It will be noticed that the upper part of the discharge passage *b* is connected with the inlet passage by a small hole *d*. The bottom of this is closed by the diaphragm *f*, held at the periphery by a hollow nut *e*. Between this diaphragm *f* and the top of the inlet valve stem is very little clearance, and as the pressure rises, even this is decreased, until finally at the maximum point, the inlet valve is held open continuously by the diaphragm. When this happens, and until the pressure is reduced, the valve is held open continuously, and the piston simply pumps out the same air which it drew in on the downward stroke.

Scat. Any one picture of a starting device of this kind would fail to show all of the component parts, for the reason that they are so scattered, some being at the front, and others at the rear of the chassis. For this reason, the diagrammatic sketch, Fig. 67, of the Scat English starter is of more than passing interest, in that it shows all of the components. In this it is rather misleading, because parts which are actually separated by several feet are shown in close proximity. Thus, the air tank is shown nearly touching the crank case of the engine. In the actual installation, the two are separated by not less than 50 inches.

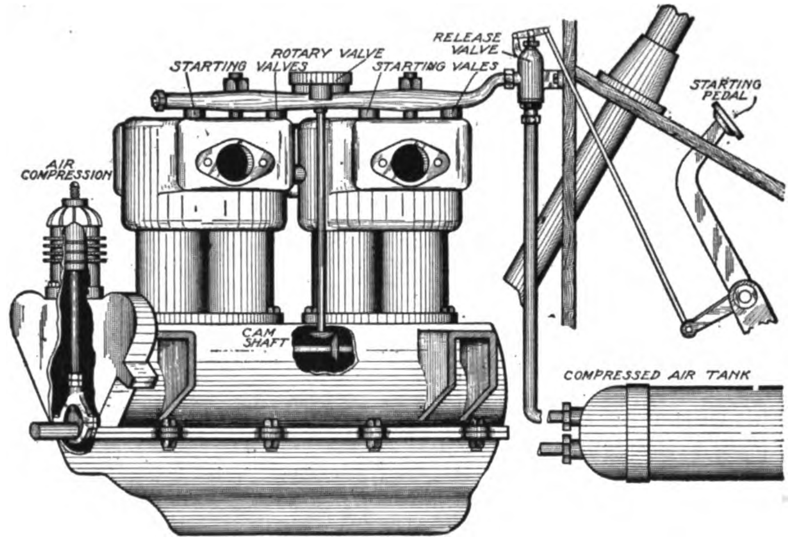


Fig. 67. Scat English Starter.

There are other systems, which, while using a part of the apparatus above described, do not use all of it, and consequently differ somewhat in their action. One that was given publicity recently is based on the assumption that when the spark and throttle are correctly manipulated just before stopping, all of the cylinders but one will contain an explosive mixture. Granting that this is so, all that is necessary is a spark in the cylinder in which the piston is in the proper position for firing. This spark is effected by disengaging the driving gear and throwing the magneto armature around to a contact, the arrangement being such that on starting, the magneto gear drops back into its proper position and ignition proceeds as usual.

A decided advantage of the compressed-air system of self-starting lies in the fact that the machine is equipped with a large tank of highly compressed air which may be found useful in many ways. For instance, for inflating tires, the autoist would take a chance on starting with less air and utilize a part of the tankful to inflate his tires.

Combined Pressure and Electric Systems. The most recent starting device is in the nature of a combination of the stored pressure and the electrically operated devices. This is an American product, made in the Middle West, and very recently placed on the market, after two years of experimentation and successful tests.

The basic idea is a source of pressure, which is admitted to the cylinders by means of a system of magnetically controlled valves. The pressure utilized is that of the explosion—not the compression, not the exhaust. This, through the medium of a pressure reducing valve, is reduced to 200 pounds, at which value the tank is filled. With a full tank, the valve cuts out the supply and the driver can then close off the valve communicating with the cylinders.

For starting, this fluid pressure is admitted to the cylinder through the medium of the distributing valves, which are placed on top of the engine as shown in Fig. 68, this being a view of the apparatus applied to an automobile engine. These valves are operated by means of an electric current, diverted from the regular ignition source, the only necessity being a direct current. This current is led through an ordinary timer and from there to the distributing valves in the cylinder heads. Thus it is that the valves are opened in proper rotation, each at the top of the piston stroke, which, while it is the correct position for the igniting spark in ordinary running, is also the correct position for the starting effort. So through the medium of the magnetically controlled valves the pressure is introduced to the proper cylinder at the proper moment. Referring to Fig. 68, *A A* are the magnetically controlled valves, to which the wires *D D* lead. *B* is the supply pipe from the storage tank. The shut-off valves *C* are operated by a hand lever on the dashboard and just above them may be seen the operating rod. If a car has a double ignition system, the battery-timer system may be used for the starting by putting the starting switch in that circuit. Then by throwing the ignition switch to the battery and timer, and the starting switch to the starting position, the gas is admitted to the proper cylinder, the engine is started; next the ignition switch may be thrown over to the running position, and the starting switch cut out.

Electrical Starting Systems. Of the three means of self-starting, the electrical method, paradoxical as it may sound, is by far the most simple. This depends for its action mainly upon two conditions and if these do not exist the starting means are useless. The first and foremost is that the piston and piston ring construction should be such, coupled with correct assembling, that the engine will always retain a compressed charge in a state of high compression. The second condition is that at low speeds, the ordinary igniting dynamo, usually called a *magneto*, is incapable of delivering a spark of sufficient intensity to ignite the mixture, *i. e.*, it must be rotated rapidly in order to be effective.

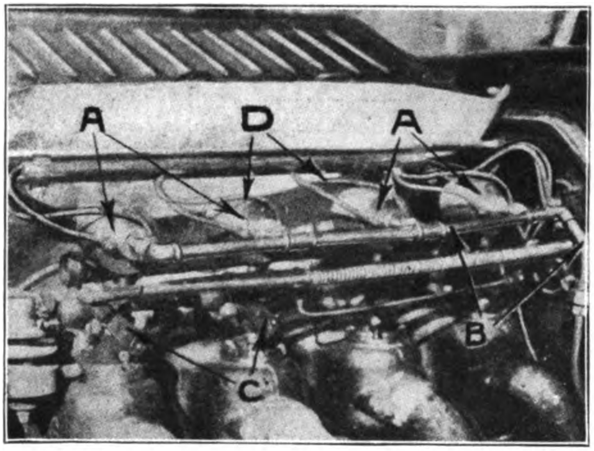


Fig. 68. Combination Electro-Magnetic Starting System.

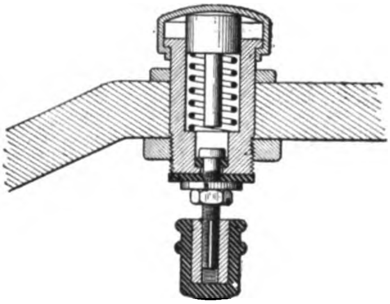


Fig. 69. Steering Wheel Starting Switch. *Bosch Magneto Company.*

The first condition is usually met by modern cars, a number of motors achieving credit by always starting on the spark, *i. e.*, they retain, upon stopping, the compression in one cylinder and may be *started* by turning on the ignition and producing a spark in that cylinder. If the ignition system fails to give a spark or the one produced is not of sufficient intensity to fire the charge, the second condition above is not fulfilled so that the first, alone, is useless for it means cranking by hand.

To fulfill the second condition, a means may be provided for rotating the magneto armature at a high speed for a sufficiently long time to ignite the charge regularly. There are two ways of doing this, both mechanical and both spring-actuated, but differing in detail. In each one of these, there is fitted some form of dashboard or steering wheel push button which sets the starter into action. One of these is shown in Fig. 69, as attached to the arm of the steering wheel so as to have the button below the arm.

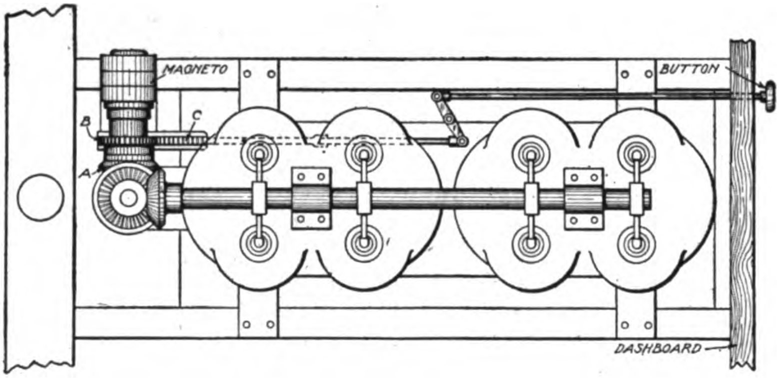


Fig. 70. Electrical Starter on the Moon Car.
Moon Motor Car Company, St. Louis.

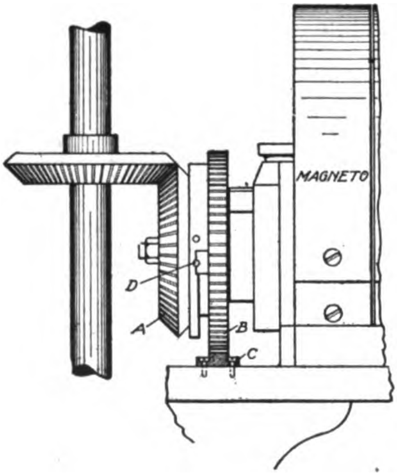


Fig. 71. Details of Rack Device on Moon Starter.

Moon. Fig. 70 shows the whole scheme of an electrical starter as applied to the 1910 models of the Moon cars, made by the Moon Motor Car Company, St. Louis, Mo., and Fig. 71 gives some of the parts more in detail. In this the magneto is located at the front of the engine crosswise of the frame, and is driven by bevel gears from the vertical shaft which also drives the overhead cam shaft. Back of the bevel gear *A* on the magneto shaft is a spur gear *B*, which meshes with the rack *C*. The latter, as seen at *C* in Fig. 70, extends parallel to the engine and is directly connected to the button on the dashboard. By pressing the button, the spur gear can be rotated backward through one-third of a revolution whereby a spring inside of the bevel gear *A* is wound. When the button is released, the spring drives the spur gear *B* and hence the magneto armature shaft upon which the gear is secured. Thus an electric impulse is generated and a spark produced in the proper cylinder. The bevel gear *A* is loose on the shaft, and the two gears have a certain relative motion, but when the spring is unwound, they are locked together by a catch or shoulder *D*, so that the armature is perfectly timed.

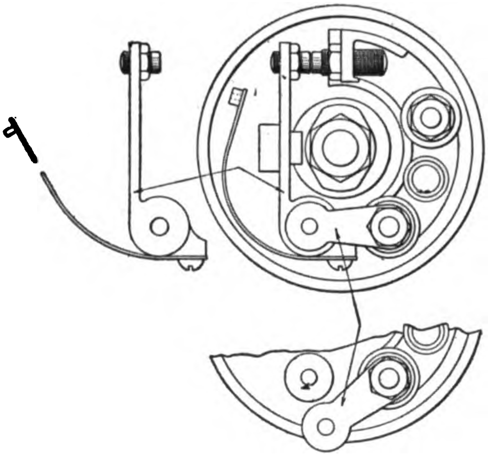


Fig. 72. Contact Breaker of the Eisemann-Lavalette (French) Magneto.

Unterberg and Hulme. A similar starter, in which a spring is used to rotate the armature when the button is pressed, is used on the Unterberg and Hulme, a German magneto imported into this country by J. S. Bretz & Co., New York City. In this, as soon as the armature has reached a suitable speed of rotation, the device is automatically thrown out of action and the armature revolves at a uniform speed.

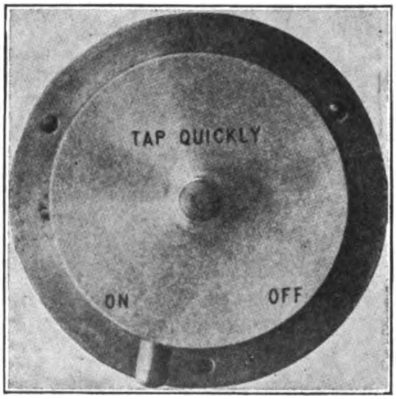
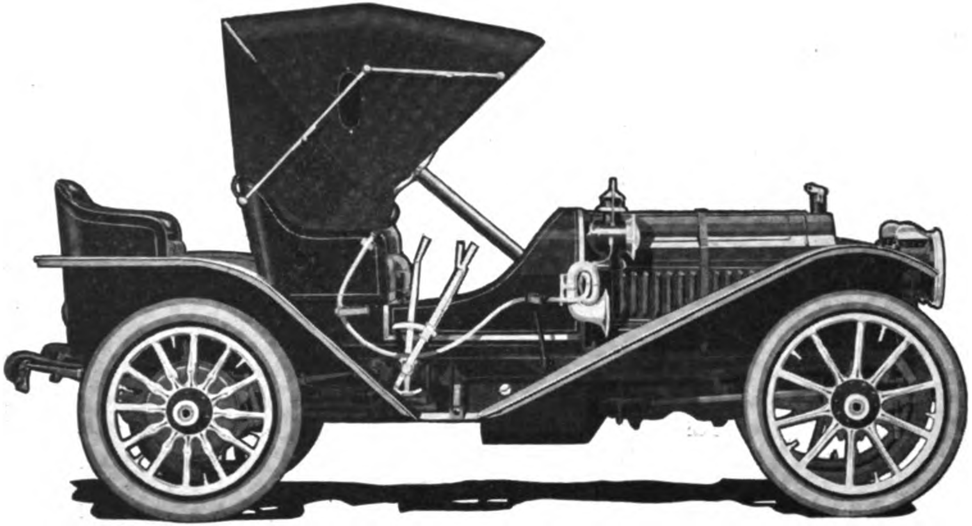


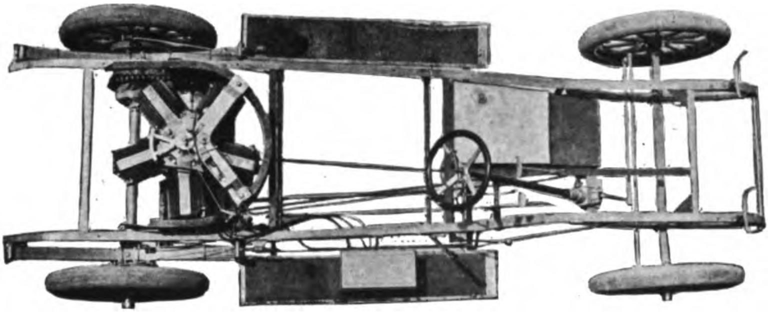
Fig. 73. Simms Switch Starter.
Simms Magneto Company, England.

Accumulator and Special Switch. In the starting mechanism put out by the Simms Magneto Company, an English firm, an accumulator or storage battery is used as the source of starting current, while a special starting switch has been developed for this purpose. The contact breaker of the magneto differs from the conventional, of which an excellent example is shown in Fig. 72. This is normally in contact; while in the Simms device the contact breaker is so designed as to have the points normally separated, causing the armature primary circuit to be opened rather than closed. By throwing the switch, shown in Fig. 73, to the *on* position, and tapping the central button quickly, a current from the storage battery is instantly passed through the primary winding, and a very quick break causes an intense spark. This usually starts the engine. After being started, the magneto runs in the ordinary manner.

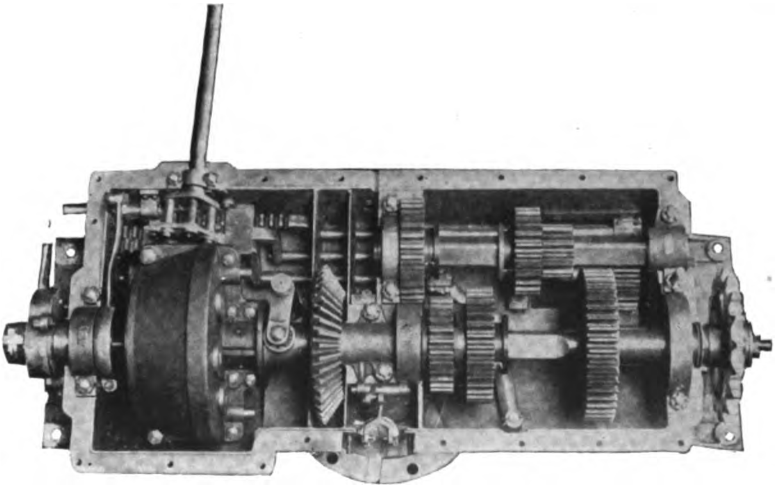
This describes the main forms of starting devices, all of which are designed to dispense with the troublesome and dangerous act of cranking an engine. After the engine has been cranked once and with a starter, which is sufficient to start the motor every time thereafter, the driver of a car is concerned principally with the transmission of that engine power to the road wheels in a manner which so conserves the energy and thus, in an indirect manner, the fuel, that the greatest speed or most power may be obtained at the least expense.



PACKARD "THIRTY" RUNABOUT WITH VICTORIA TOP
Packard Motor Car Co., Detroit, Mich.



CHASSIS OF ADAMS REVOLVING-CYLINDER MOTOR-CAR
The Adams Company, Dubuque, Iowa.



TRANSMISSION GEAR AND CONTROLLING MECHANISM OF THE ADAMS CAR
The Adams Company, Dubuque, Iowa.

AUTOMOBILE MECHANISMS

PART II

CLUTCH

Principal among the indispensable parts which intervene between the engine and the road wheels, and which may be a source of great joy or correspondingly great wrath if it be well or poorly designed and fitted, is the clutch. There are six forms into which clutches may be divided, although not all of them are in general use in the automobile. In general, only the first four are used on automobiles. These different forms are:

1. Cone clutches.
2. Band or drum clutches.
3. Expanding ring clutches.
4. Disk and friction clutches
5. Hydraulic or fluid clutches.
6. Magnetic or electric clutches.

The necessity for a clutch lies in the fact that the best results are obtained in an automobile engine when run at constant speed. Inasmuch as the speed of the car cannot, from the nature of its use, be constant, it requires some form of speed variator. This is the usual gear box or transmission, but in addition, there is the necessity of disconnecting this from the motor upon starting since the engine cannot start under a load. There is also the necessity for disconnecting the two when it is desired to change from one speed to another either by way of an increase or a decrease. So, also, when one wishes to stop the car, there must be some form of disconnection. There are then three real and weighty reasons for having a clutch.

Cone Clutch. In its simplest form this consists of two members, one fixed on the flywheel or other rotating part of the engine, the other fixed to the transmission shaft. The latter usually slides upon the shaft so as to allow engagement and disengagement. A spring

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holds the two together or apart, according to the type of clutch used. When the smaller diameter member is spoken of, it is usually called the *male member*, while the part of larger size is spoken of as the *female member*.

The cone type is found to be made in two different varieties, the one in which the male member enters the female naturally at the open end, which is called the *direct* cone type. In the other form, the male is set within the structure of the female and is pressed outward toward the open end to engage it. This is called the *inverted*, or sometimes the *reversed*, cone clutch.

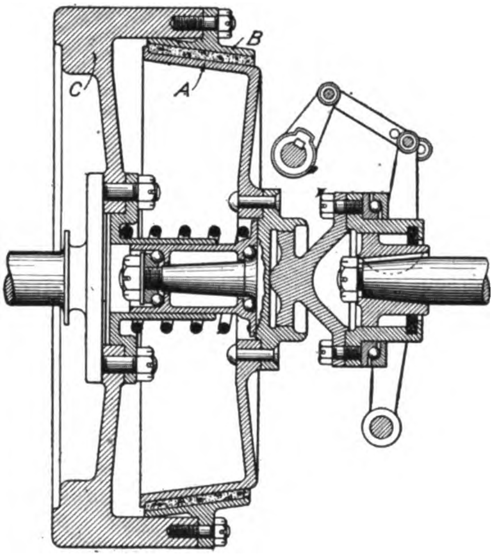


Fig. 74. **Cadillac Reversed Cone Clutch.**
Cadillac Motor Company, Detroit, Mich.

A big disadvantage of the inverted form is that the spring must be carried between the two cones, which means that it is inside where it cannot be reached for adjustment. Fig. 74 shows this clearly. This form causes trouble in assembling because the male cone *A* must be put in place with the spring between it and the flywheel *C*, before the female *B* can be set into its place and bolted up. These two big sources of trouble have caused the designer to turn to the direct type more freely, as it lends itself readily to an external adjustment. If the spring is outside it is easily put into place and as easily taken out. Fig. 75, which illustrates this, is a section through the Clement-Bayard clutch, and the spring is seen to be entirely outside of the clutch proper. Its location is such as to permit the adjustment of the tension at any time, by means of a screw collar *C* which may be done with no more trouble than lifting up the footboard of the car, and turning the collar forward a few turns.

Not all designers have hit upon as happy a solution of the clutch problem as this. Thus, in the Studebaker clutch, shown in Fig. 76, the spring *B* is external to the clutch but so placed that it is necessary to disconnect the universal joint *A A*, take it off the car, loosen a set screw, adjust, and then repeat the other operations in reverse order. A similar state of affairs is found in the Benz, illustrated in Fig. 77, in which it is necessary to take out the bolts connecting the shifting collar to the male member, and then, through the longitudinal motion permitted by the form of universal joint used, slide this backward as far as possible. The latter movement allows of removing it from place, then the spring tension may be adjusted by simply removing a cotter pin.

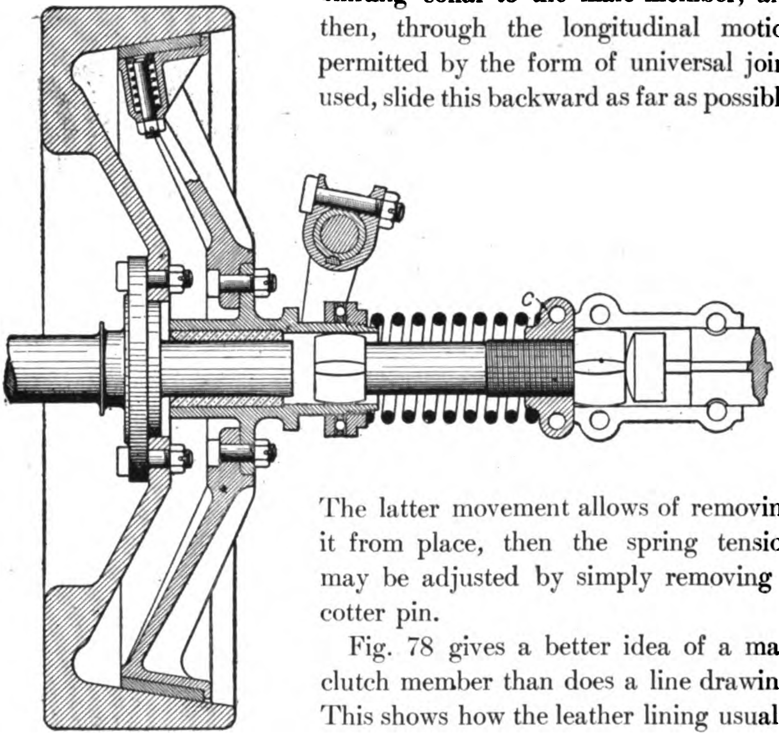


Fig. 75. Clement-Bayard Direct Cone Clutch.

Fig. 78 gives a better idea of a male clutch member than does a line drawing. This shows how the leather lining usually used is fastened to the metal ring or spider by means of rivets. In the up-to-date car this method will be found to have been carried even farther than this, the leather being put on in sections, so that in case of unequal wear a single, worn-out section may be replaced without disturbing the others. An even later idea emanates from England and is nothing less than putting these sections onto the cone by means of dovetails. In this way a worn section can be replaced in the length of time that it takes to tell about it.

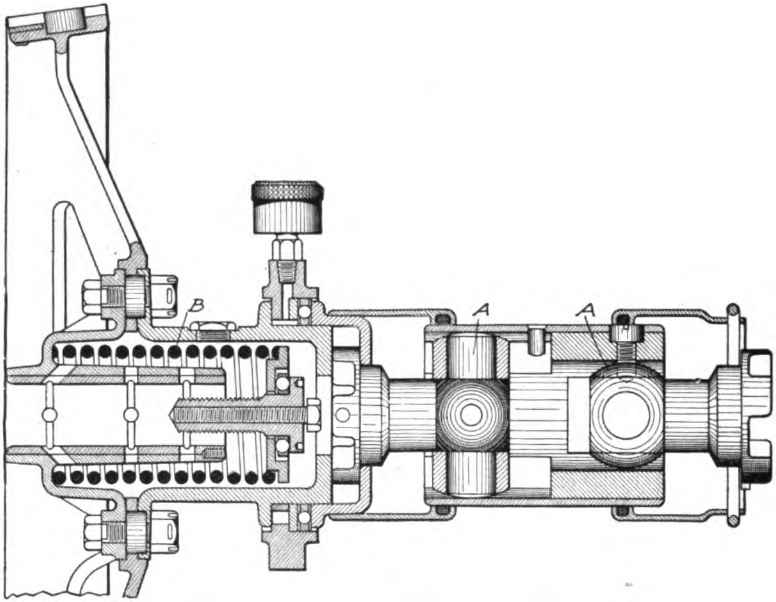


Fig. 76. Studebaker Direct Cone Clutch.
Studebaker Automobile Company, South Bend, Ind.

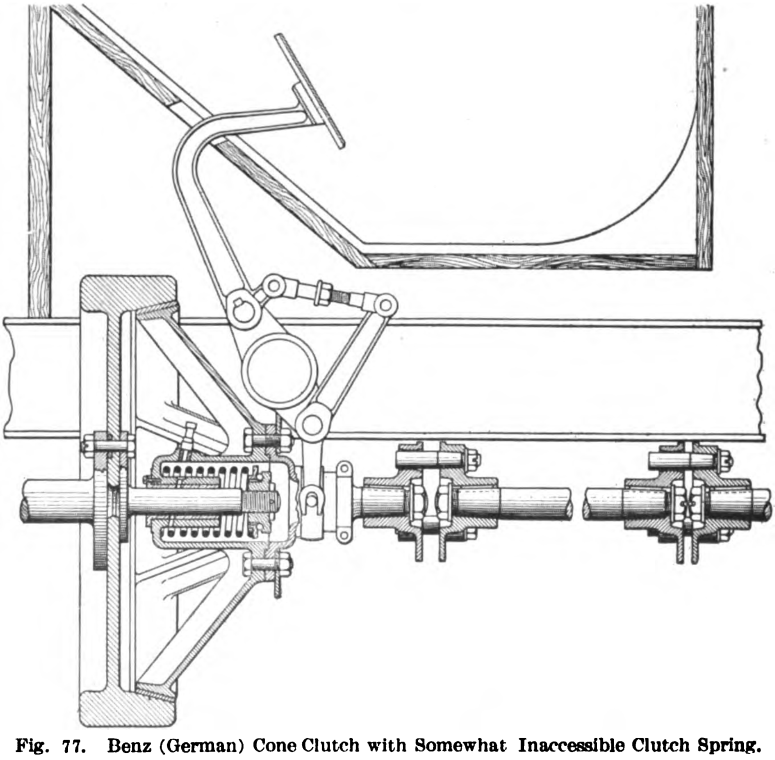


Fig. 77. Benz (German) Cone Clutch with Somewhat Inaccessible Clutch Spring.

Requirements Applying to All Clutches. In a serviceable clutch there are two general requirements which are applicable to all forms. These are *gradual engagement* and *large contact surfaces,* although the latter requirement may be made to lose much of its force by making the surfaces very efficient. In the cone clutch, gradual engaging qualities are secured by placing a series of flat springs under the leather or clutch lining. By means of these springs, acting against the main clutch spring, the clutch does not grab, since the large spring must have time in which to overcome the numerous small springs. In this way the engagement is gradual and the progress of the car is easy but continuous.

The specific necessity in a cone clutch, whether it be direct or inverted, is a two-fold one—*sufficient friction surface,* and *proper angularity.* As the latter, in a way, effects the former, as will be discussed more in detail later, this really reduces to one complex requirement.

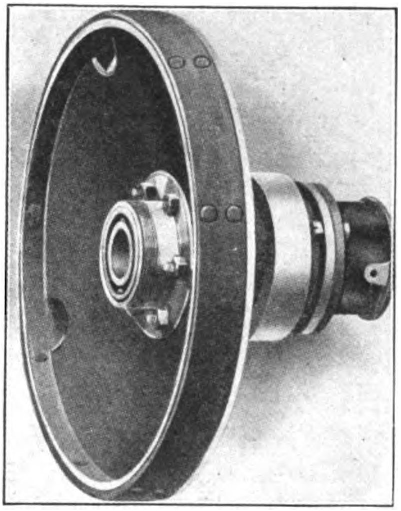


Fig. 78. Male Portion of Royal Clutch. Uses Narrow Leather to Carry Load.

The angularity varies in practice from 10 to 18 degrees. In arriving at these figures, a line of reasoning is followed somewhat like the following:

The force of the spring acts along one leg of a right triangle of which the resulting useful force is found to lie along the hypotenuse, the latter being perpendicular to the surface of the clutch. In this case, the ratio of the resulting useful force x to the original spring pressure A is the ratio of 1 to the sine of the angle of the clutch cone θ. Expressed in the form of proportion, it is

$$X : A :: 1 : \sin \theta$$

or as an equation

$$\frac{X}{A} = \frac{1}{\sin \theta}$$

Since 1 is a constant, reducing sin θ increases the ratio. Reducing the sine, in turn, means reducing the angle itself, and this is the course usually pursued as a large ratio is the desired quantity. For this reason small clutch-cone angles are used. The actual angle is, however, partly determined from another basis.

Coefficient of friction is the name given to the adhesion of two materials one to the other, under just such conditions as are described above. Since it is impossible to have perfect adhesion, this coefficient is always less than unity. Now, the angle of the cone of a cone type clutch is dependent solely upon the coefficient of friction of the materials selected and the condition of the friction surfaces. Quite frequently, in fact, usually, the materials of cone clutches are leather and cast iron; *i. e.*, the female cone is either a part of a cast-iron flywheel or made of cast iron, while the male cone is usually some other material lined with leather. The ordinary male cone is of very light metal so as to reduce the spinning action of this rapidly rotated mass. Of late years, aluminum has met with favor for this part.

The coefficient of friction for cast iron and leather has been determined as .30 dry, and .25 greased. Since the latter case is more usual this value will be used. Expressed mathematically, the coefficient of friction is the tangent of the angle of repose, so for this value it would be the angle of which .25 is the tangent. This is 14 degrees. A more conservative value of the coefficient is .20, for which the angle is but 11 degrees.

In the design of the clutch, however, a more accurate method than this is pursued. The twisting moment in foot pounds M is equal to the horse-power P, reduced to foot pounds, divided by the speed at which the power is to be transmitted. This gives the equation

$$M = \frac{P\ 33{,}000}{2\ \pi\ R}, \text{ or roughly, } \frac{P\ 5250}{R}$$

Let S represent the torsional resistance, to which the clutch must at least be equal, and F the mean or average radius of the male cone in inches; then

$$S = \frac{P\ 63{,}000}{F\ R}$$

If now, the resulting pressure from the clutch spring acting normal to the clutch surface is z, the axial pressure or total exerted by the spring is x, and the coefficient of friction is f, then

$$z = \frac{x}{\sin \theta} \text{ and } S = z f = \frac{x f}{\sin \theta}$$

Equating the two values for S, and solving for x

$$x, \text{ spring pressure} = \frac{P\ 63{,}000 \sin \theta}{F R f}$$

and solving for P

$$P, \text{ power transmitted} = \frac{x f F R}{63{,}000 \sin \theta}$$

Band Clutch. A simple and short consideration of the band style of clutch shows that this does not differ radically from the ordinary band brake, either in construction, application, or actual working. The difference in the two lies in the fact that the band as a clutch is designed to transmit power with as little loss as possible while the band as a brake is designed to absorb the forward energy of a moving vehicle (equal in the last analysis to power) in the shortest possible space of time, *i. e.*, to waste as much power as possible.

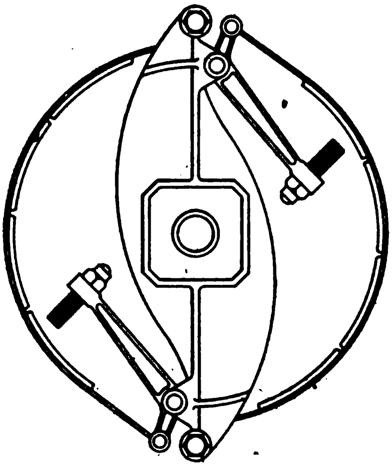


Fig. 79. Mors (French) Contracting Band Clutch.

Fig. 79 shows the form of band clutch used on the Mors, French cars, but manufactured in this country by the St. Louis Car Company, St. Louis, Mo., under license from the parent firm. In this form, the band is in two parts and a rocker arm moved by a sliding cone operates the free ends of the two bands which thus contract upon the clutch drum. Fig. 80 is a drawing of the clutch used on the Gaeth cars, made in Cleveland, Ohio, by Paul Gaeth. While not differing radically from the Mors, this has the two sections of the band united at the bottom and the two operating levers are pivoted at the top, where a single conical-shaped cam moves both outwards and tightens the bands on the drum.

In Fig. 81 is shown the Reliable Dayton clutch, which is very similar to the Gaeth just described, the differences being very minor ones of construction. Neither one of these clutches appears to have any great width, but in Fig. 82 is shown a type of band clutch in which this fault is corrected, a considerable width being provided. The most usual place in which the band clutch is found is in connec-

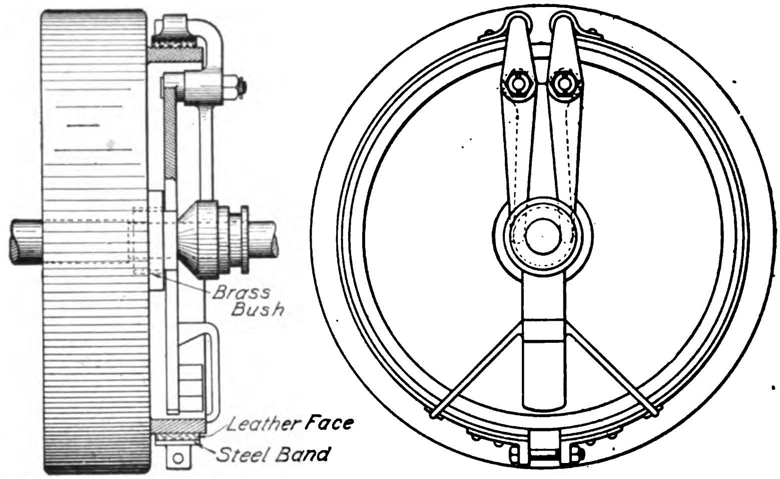


Fig. 80. Gaeth Contracting Band Clutch.
Gaeth Automobile Company, Cleveland, Ohio.

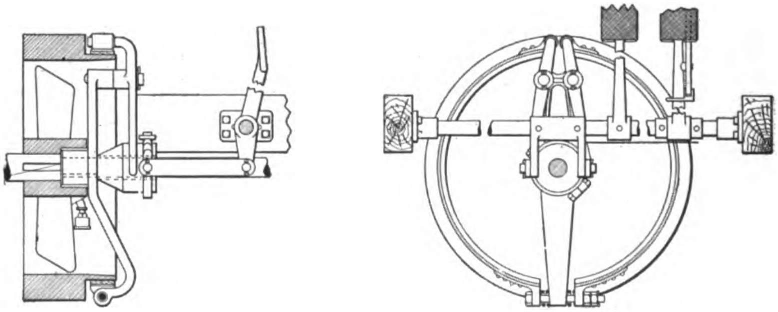


Fig. 81. Reliable Dayton Clutch.
Reliable Dayton Automobile Company, Chicago, Ill.

tion with a planetary transmission. There the band is always used, and there it reaches its simplest form, that of the plain band wrapped around the drum. One end is fixed and the other attached to the braking, or more correctly, the clutching lever. A plain pull on this effects the clutching action. A more modern and more efficient form has one end of the band attached to one extremity of the clutching lever, while the other end of the band is fastened to the middle of this lever. The clutching pull comes upon the upper extremity of the lever. Then the band acts to aid in clutching itself, *i. e.*, a scissors action is obtained, and the required pull is lessened.

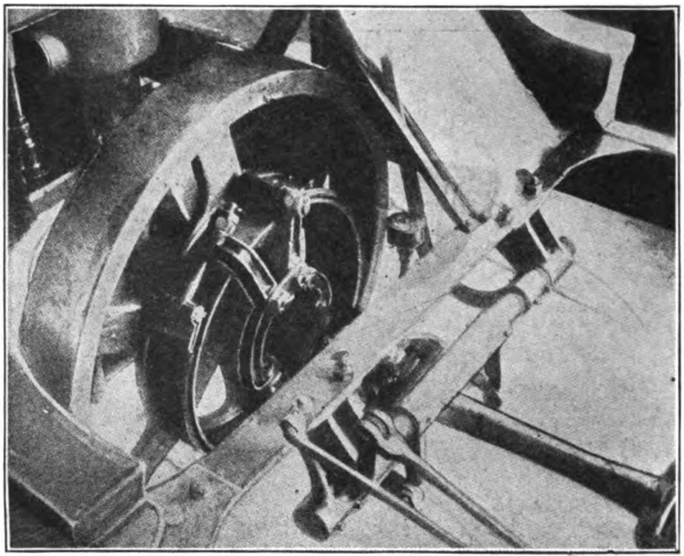


Fig. 82. Particularly Wide Band Clutch.

When the band is used as a brake the pull necessary to stop the car is

$$p = f w \frac{D}{d}$$

in which f is the coefficient of friction, w the weight to be stopped, D the diameter of the road wheels, and d the diameter of the brake drum. Now the ratio of the diameter of the road wheels to that of the drum is but the ratio of the work arm to the power arm, so when the band is used as a clutch, the ratio of the radius of the two arms may be substituted. The power arm is taken as unity and the work arm as the radius of the clutch drum. Since this divided by 1 remains the same, it may be substituted in the formula above. So, too, with the weight, in place of this must be substituted the power to be transmitted, which is the equivalent of the weight in the other case. The formula then becomes

$$p' = f P r$$

Owing to the winding action of the band, the pull p' will be less than the pull p, by an amount which varies as the portion of a circle or number of degrees encircled by it. Then taking θ as the number of degrees

$$\frac{\log p}{\log p'} = .434 f \theta$$

from which the value of p' may be evaluated in terms of p and substituted in the previous formula.

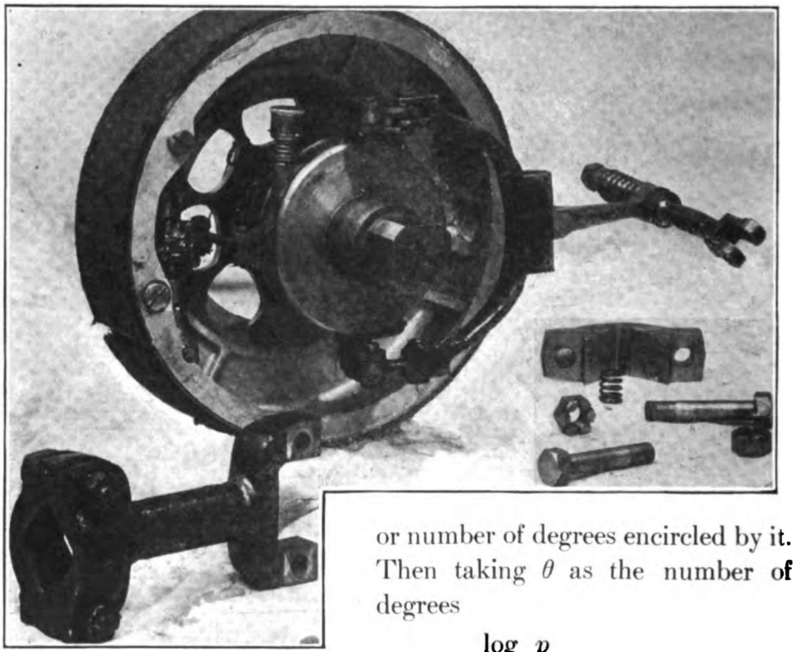


Fig. 83. Peerless Expanding Band Clutch.
Peerless Motor Car Company, Cleveland, Ohio.

Ring Clutch. In actual numbers, the expanding band form of clutch finds little favor. Like the contracting band, which is very similar to the band form of brake, the expanding band is very much like the expanding type of brake, with the exception that the clutch is used to form the connection between two rotating parts. Viewed from the standpoint of pure engineering, the expanding band is very little different from the cone type of clutch, granting that the angularity of the operating cam is the same as that of the cone.

Much depends upon how the band is expanded, the methods differing widely in practice. This is usually accomplished by means of screws which may be either right-handed, or left-handed, or both. In the Benz-Parsifal clutch, the screws are single and right handed. This superinduces a gain in the power required to clutch by the amount of

$$A, \text{gain in power} = \frac{2\pi l}{s}$$

in which l is the length of the lever in inches, and s the pitch of the screw in inches. If the screw is made double, *i. e.*, one-half threaded right hand and the other half threaded left hand, then the expression should be halved. This latter case being more usual, it will be of interest to resolve the gain into the original formula for power, *i. e.*,

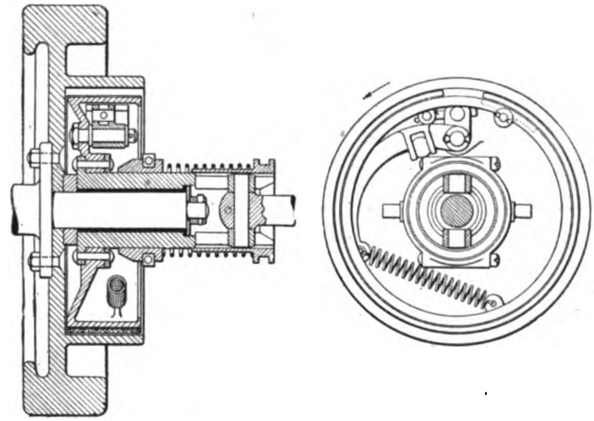


Fig. 84. Expanding Band Clutch. Formerly Used on the Wayne.

$$P = \frac{f F R x l}{63{,}000\, s}$$

The Peerless clutch, Fig. 83, used on the Peerless motor cars, has the band expanded by a double-threaded screw, which is operated by a lever. This, in turn, is moved by a pair of sliding collars on the main clutch shaft, the clutch foot pedal moving these forward. Differing slightly from this is the clutch which was used on the Wayne cars, when they were built and sold. This, Fig. 84, consists of a band with one fixed end. To the free end is attached a short expanding link. The latter is operated by means of a sliding cone on the main shaft. Moving this forward has the effect of moving the roller outwards. To compensate for this outward movement, the spring pulls the inner end farther in, and the expanding link opens the band against the drum.

The difference between the clutch which is shown in Fig. 85 and those preceding, lies in the fact that both ends of the band are free and the movement of expansion is halved. This is brought about by a single toggle lever attached to a sliding collar. Moving this forward has the effect of opening up the pair of levers at the outer end, which pushes the two bands apart, one lever being attached to each band. As an adjustment for wear, one arm is not rigidly fixed to the band but is fastened to it by means of a screw connection with a locking device which makes its position positive. This is the clutch used on the truck built by the Frayer-Miller Company, Springfield, Ohio.

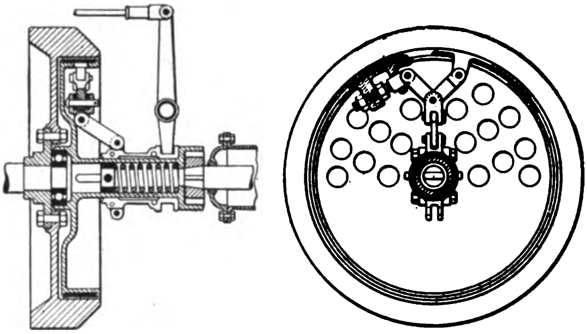


Fig. 85. Frayer-Miller Commercial Car Clutch.
Oscar Lear Automobile Company, Chillicothe, Ohio.

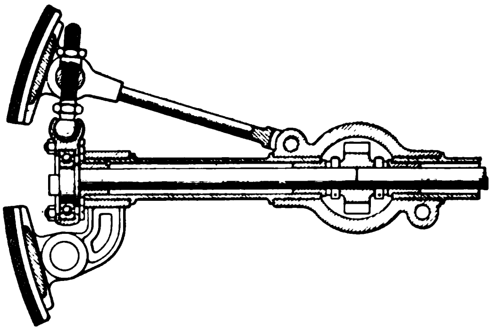


Fig. 86. Stearns Segmental Band Expanding Clutch.

On the Stearns car, made by the F. B. Stearns Company, Cleveland, Ohio, is to be found a decidedly different form of expanding ring clutch. This does not have a complete band but only a pair of segments. These, as shown in Fig. 86, are jointed to the clutch spider at one end, and are operated by a pair of eccentrics, one at each end of two shafts coupled at the middle by a shaft driving pinion. This is engaged by a spring and treadle actuated rack. Although strange in appearance, this clutch operates very nicely.

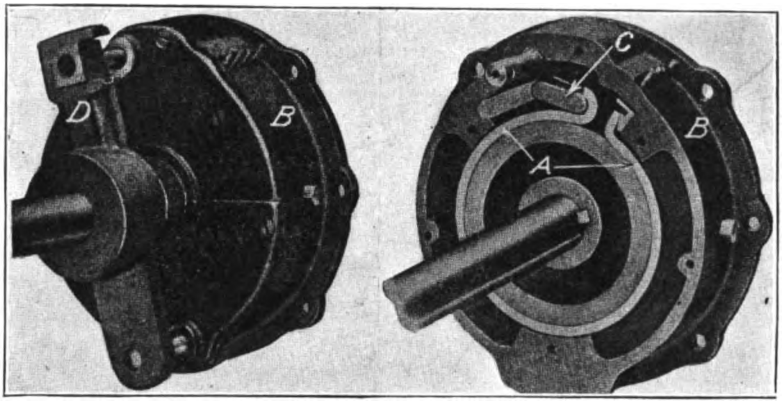


Fig. 87. Warner Expanding Clutch. *Warner Mfg. Co., Munice Ind.*

In all the preceding clutches, the band has been a flexible one of very thin sheet steel, in most cases covered with some form of renewable lining. In the Warner clutch, illustrated in Fig. 87 and Fig. 88, the band is composed of a number—from four upwards, according to the power transmitted—of wide, thick, steel rings *A*. These are placed within a chilled iron drum *B*, and are expanded by means of a very long, powerful lever *D*. The diameter of the rings is not large and where the diametral space is limited while the longitudinal space is not, this form finds an excellent opening, the multiplication of the number of bands taking care of any reasonable power requirements.

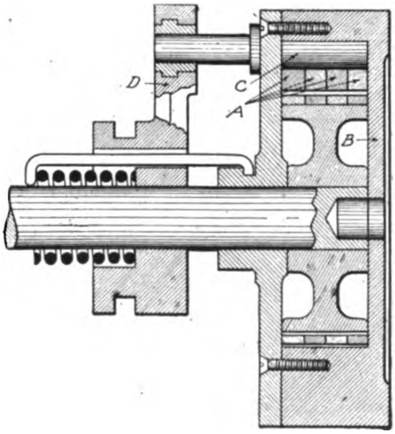


Fig. 88 Section of Warner Clutch.

The Koechlin clutch is perhaps twenty years old in principle but, as adapted to modern service, it takes a somewhat modified form, as shown in Fig. 89. This is but a segmental expanding band with three segments. Naturally this requires three toggle movements to operate, each one of these operating two ends, which accounts for all six ends of the three bands. The original form used metal to metal surfaces, but the expanding segments are now usually covered with strips of wood which correspond to the leather lining of other clutches.

A peculiar clutch, which has some of the qualities of both the contracting and expanding band, is shown dissembled in Fig. 90 and assembled in Fig. 91. This clutch is used in the Tincher car, made by the Tincher Motor Car Company, South Bend, Ind., and is called by the makers a *contracting band.* It is of metal throughout, the flywheel being of steel, the clutch of steel, and the clutch drum of manganese bronze. The latter is bolted to a flange on the end of the driving shaft, which is perfectly circular in section. The clutch band is made with a series of teeth cut into a part of the exterior surface close to the cut which divides the band. On the other side of the cut, a lip or projection is cut upon the surface of the band which slides into a similar but opposite slot in the interior of the flywheel. In this way, the band is constrained to rotate with the latter. In the flywheel is also cut a series of teeth to correspond with those on the band and so located as to come directly over them when the two are assembled. The operating lever is made an integral part of what is really a long spur pinion of very small diameter,

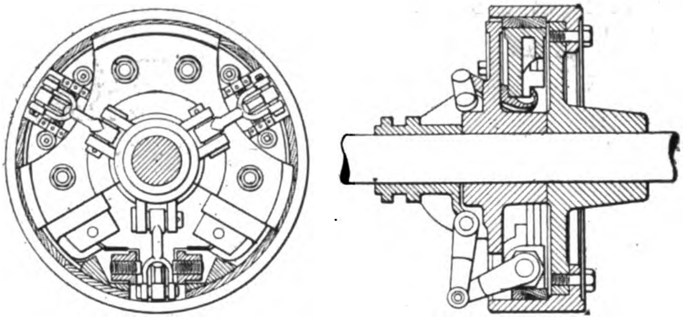


Fig. 89. Modern Koechlin Clutch—Wood Against Metal.

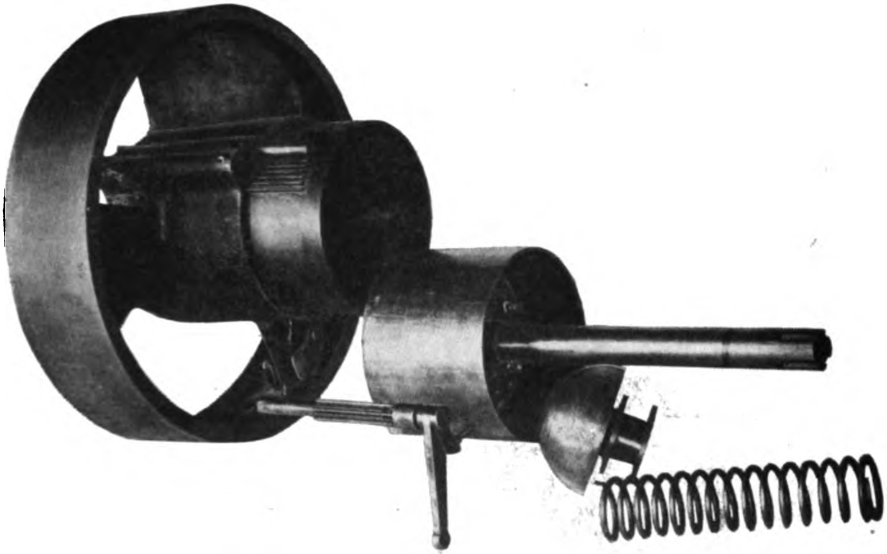


Fig. 90. Tincher Contracting Band Clutch Dissembled

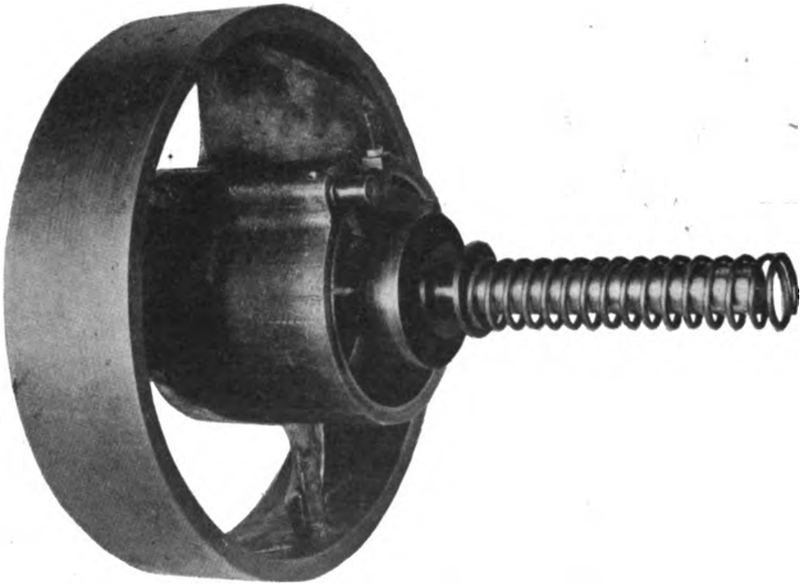


Fig. 91. Tincher Band Clutch Assembled.
Tincher Motor Car Company, South Bend, Ind.

the teeth matching those in the flywheel and upon the band. Sliding a cone forward upon the main shaft turns this lever and with it the pinon-shaped end. This being engaged with fixed teeth in the flywheel, which cannot move, and with the teeth on the band, which being flexible due to the cut, can move, the result is that the band is wound up smaller until it grasps the drum on the end of the main shaft. Since the natural spring of the cut band always opposes the winding action, the clutch releases very readily, but a very strong spring, stronger than usual, is necessary to force it into engagement.

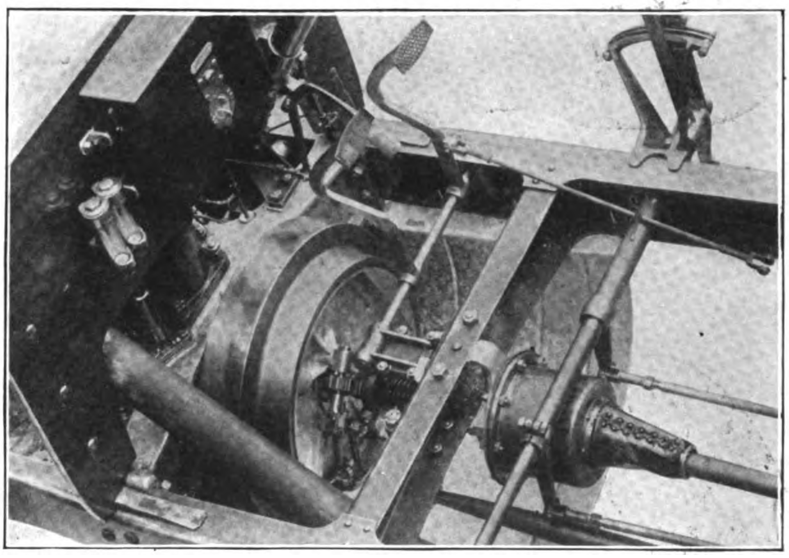
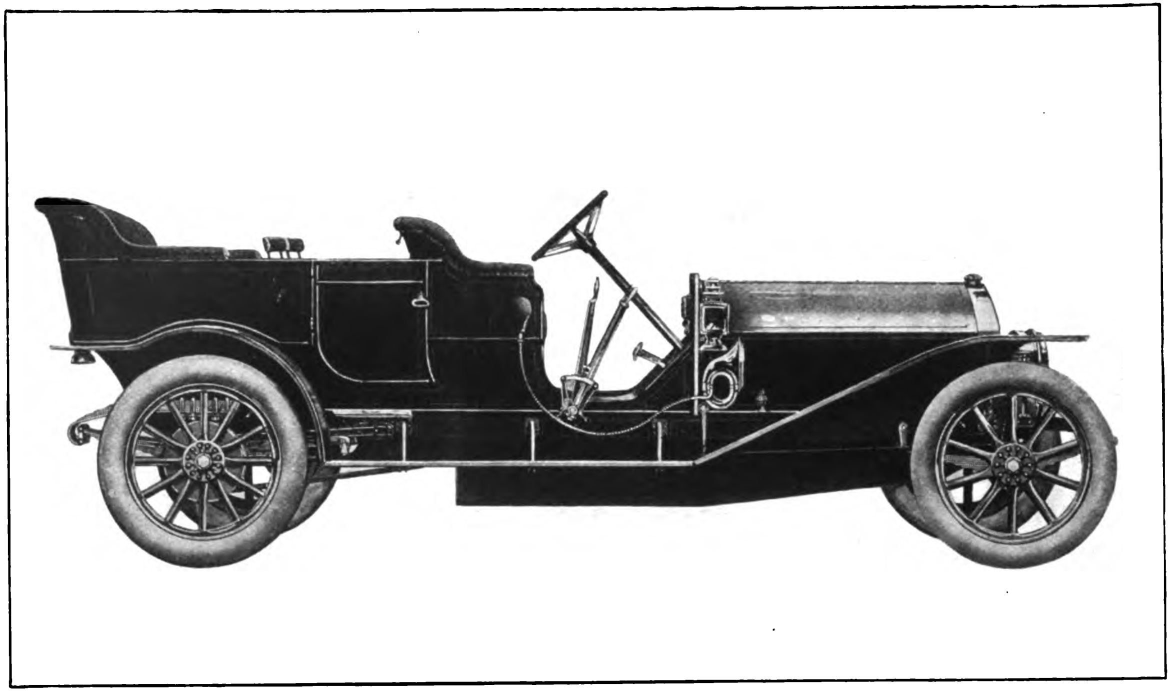


Fig. 92. Packard Clutch Showing Small Operating Pinion.
Packard Motor Car Company, Detroit, Mich.

The expanding band clutch, Fig. 92, used on the Packard car, made by the Packard Motor Car Company, Detroit, Mich., is very similar to the Peerless clutch, Fig. 83. This similarity is not strange when it is considered that the same man, Charles Schmidt, designed first the Packard, and later the Peerless clutch. There is this difference, however, in the Packard—the movement of the operating lever attached to the right- and left-hand threaded screw, which spreads the bands, is obtained from a gear. This is of very small diameter, and is rotated by sliding forward a small rack with which it is in mesh. The rack is attached to the clutch fork, operated by the foot pedal, so that, when the pedal is moved forward to disengage the clutch,



PREMIER "SIXTY-SIX" SEVEN-PASSENGER TOURING CAR
The Premier Motor Mfg. Co., Indianapolis, Ind.

the rack is drawn backwards. This rotates the gear, pulls the band open against the strength of the spring, and thus frees the engine from the transmission.

Disk Clutch. With its advent in 1904, the multiple disk clutch has steadily grown in popularity until today, it is looked upon as the most satisfactory solution of the difficult clutch problem. Designers who have once adopted it, seldom, if ever, go back to another form, while of the new cars coming out from time to time nearly three-fourths are equipped with some form of disk clutch.

These differ in number and shape of disks, method of clutching, declutching, material, and lubrication, but in principle all are alike. This principle, briefly stated, is that *flat surfaces properly pressed together will transmit more power with less trouble than any other form.* By multiplying the number of surfaces and making them infinitely thin, the power transmitted may be increased indefinitely. That this is not idle fancy is shown by a number of very successful installations of 1,000 horse-power and over in marine service, and certainly no such power is required for an automobile.

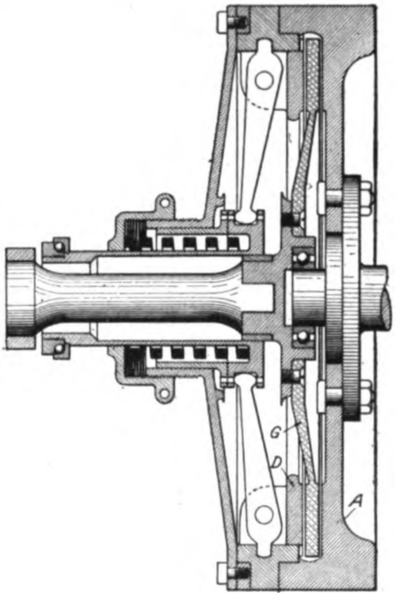


Fig. 93. Austin Clutch with Single Disk.
Austin Automobile Company, Grand Rapids, Mich.

The minimum number of plates in use is said to be three, but very often the construction of a three-plate clutch is such that one or two surfaces of other parts are utilized, making it a two or even one-plate clutch in reality. Thus, in the Austin clutch, shown in Fig. 93, made by the Austin Automobile Company, Grand Rapids, Mich., a copper disk *G* of some thickness is clamped by spring pressure between the flywheel *A* and a floating ring *D*. In reality, the copper disk transmits all of the power, the flywheel being a necessity and the floating disk only an accessory before the fact.

It would, therefore, not be wrong to call this a *one-plate* clutch.

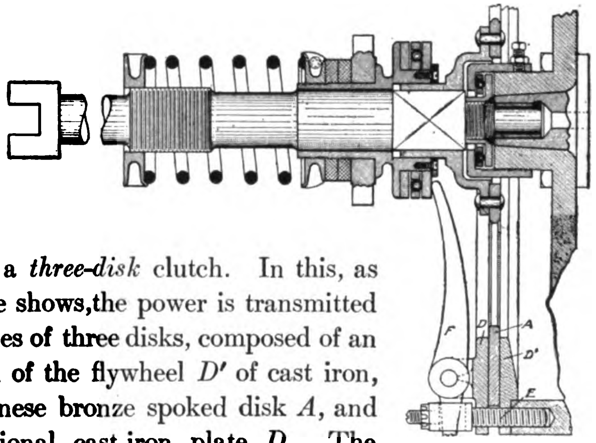


Fig. 94. Thomas Single Disk Clutch.

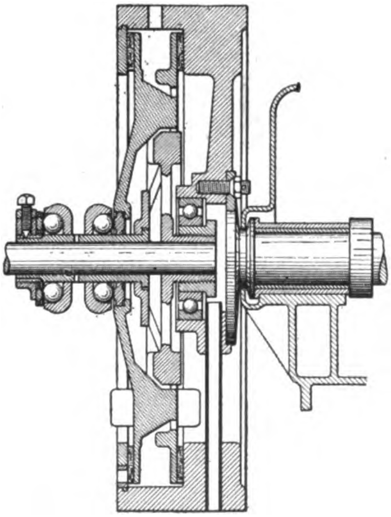


Fig. 95. Cadillac Two-Disk Clutch.

So, too, with the clutch which is seen in Fig. 94. This is the product of the E. R. Thomas Motor Company, Buffalo, N. Y., and is called a *three-disk* clutch. In this, as the figure shows, the power is transmitted by a series of three disks, composed of an extension of the flywheel D' of cast iron, a manganese bronze spoked disk A, and an additional cast-iron plate D. The levers F have their lower ends pressed inwards by the spring pressure. The bolts E carry at their outer ends slots, in which the upper ends of the fingers F rest. Since the middle portion of these fingers rests against the plate D, the spring pressure on the lower end presses this plate inward against the bronze disk, and in this way, the clutching action is obtained. Upon close analysis, the disk D' is seen to be no more than a face of the flywheel, so that it would not be incorrect to call this a *two-disk* clutch. Another clutch, shown in Fig. 95, might well be called a *two-plate* although it is spoken of as a *three-plate*. This is the clutch used on the Cadillac cars, made by the Cadillac Motor Company, Detroit, Mich. There are two disks faced with leather, which act against the cast-iron flywheel and an inserted cast-iron disk.

Multiple Disk Clutches. The modern tendency in disk clutches, however, is away from those of few plates requiring a very high spring pressure—since the friction area is necessarily limited—towards the multiple disk variety, in which a very large area is obtained. This allows of a very light spring pressure and consequently is easier to engage and disengage and for this reason, it is becoming more popular with owners and drivers than the variety requiring the extra heavy effort. The construction of this type of three-plate disk clutch does not differ radically from one maker to another, as is shown by the two end views, Fig. 96 and Fig. 97. In each of these, three fingers are used to clutch and declutch, the amount of movement being ad-

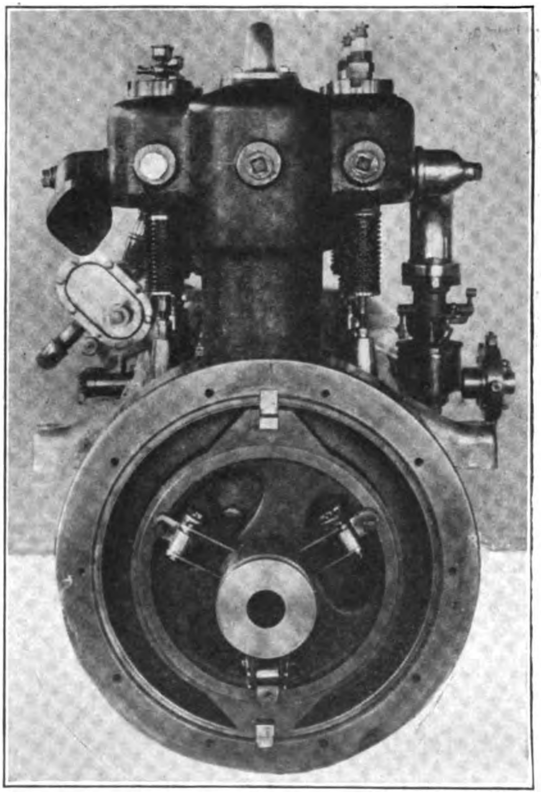


Fig. 96. End View of Three-Plate Clutch.

justable. In both of these a single spring of large diameter and large sized wire is used as a source of spring pressure and cast iron

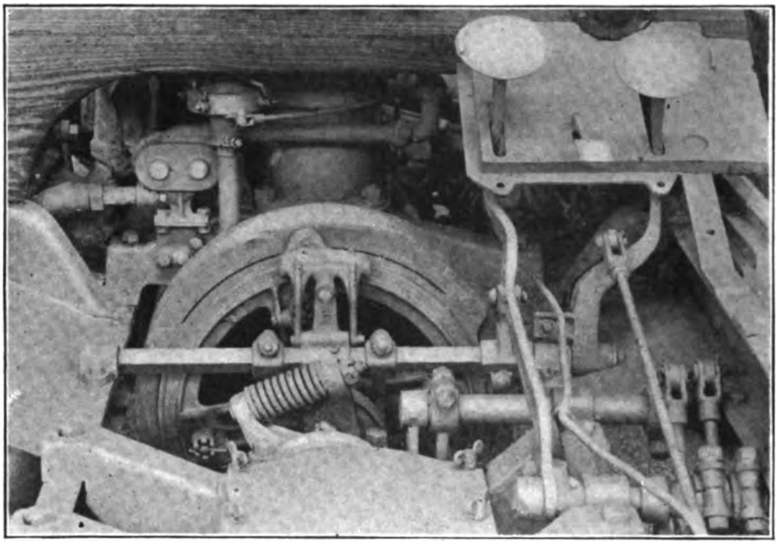


Fig. 97. Exterior of Midland Disk Clutch and Control.
Midland Motor Company, Moline, Ill.

is the material of one-half of the clutch plates. Since the smal number of disks require a large spring pressure, a considerable foot

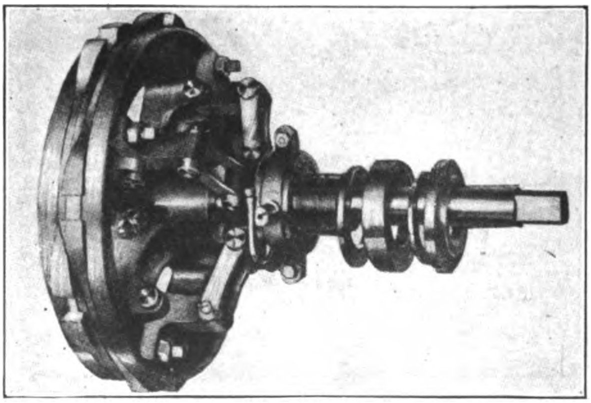


Fig. 98. Five-Plate Clutch of Bay State Car.

pressure is necessary to disengage. This defect has led many makers to take up the large number of disks, or the true multiple disk clutch.

With a large number of plates and consequently a very large surface area, the spring pressure may be very light which makes declutching very easy. In the scale between the so-called *three-plate* and the true *multiple disk,* there are many graduations. One at the lower end of the scale is seen in Fig. 98, which is the clutch of a car built in New England a few years ago but which is now discontinued. In it are used five disks, three of steel between which are two of bronze, the latter being fitted with cork inserts. The ability of the five disks of moderate diameter may be judged from the fact that the device was called upon to carry 40 horse-power with very low spring pressure

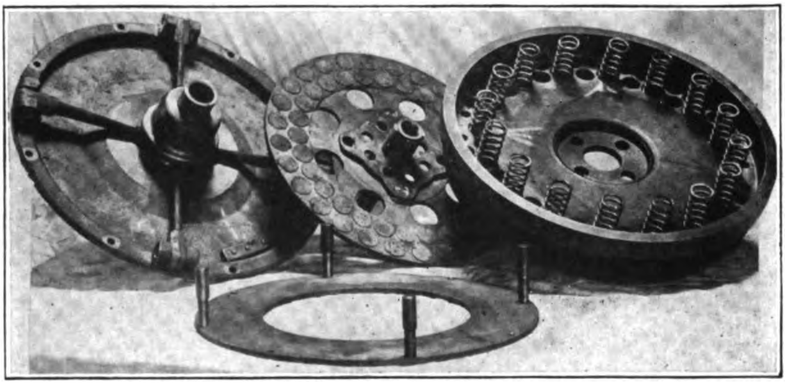


Fig. 99. Dissembled Knox Clutch.
Knox Automobile Company, Springfield, Mass.

In the true multiple plate clutch, there are three general varieties met with in practice: the metal to metal with straight faces; the metal to metal with angular or other shaped faces designed to increase the holding power; and the straight face kind in which metal does not contact with metal, one member being either lined with a removable lining or else fitted with cork inserts. The latter may be seen with clearness in Fig. 99. This shows the clutch of the Knox automobiles, made by the Knox Automobile Company, Springfield, Mass., one of the pioneer companies. This clutch is shown dissembled, the piece at the left being the external part and carrying the four arms or fingers which operate the clutch. At the right is the housing, which in this case is the flywheel of the engine as well. It contains the springs, sixteen in number, small in diameter, and very short. Between the two may be seen the clutch plate with its fifty large-sized cork inserts, the latter forming two rows around the outside of the plate.

The method of fitting the clutch with cork inserts, as in this case, is one which almost invariably calls for the making of the one set of disks of steel stampings, while the other set is usually made of castings, bronze being given the preference. This rough description aptly covers the clutch of the Stevens-Duryea Company, makers of the Stevens-Duryea cars, shown in Fig. 100. This firm was one of the first to bring out and advocate a disk clutch, which it did in 1904, and it has been continued unchanged.

From the very nature of the form of construction used by the Stevens-Duryea Company, it is impossible to have the clutch within the flywheel, which is the usual case. This method has the additional advantage that the central part within which the clutch is housed is very small in diameter, so that the portion of the flywheel between the rim and the clutch housing may be made in the form of fan spokes, thus converting it into a fan and serving to cool the motor better.

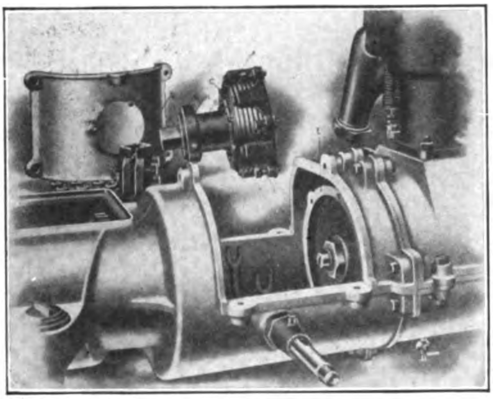


Fig. 100. Stevens-Duryea Dry-Disk Clutch.

Many designs follow this method, among which a few prominent examples are shown. In Fig. 101 is seen the clutch used by the famous French constructors, Panhard and Levassor. This is of the all-metal type with plane faces. In the same category is the clutch shown in Fig. 102, which is used on the French, Westinghouse car.

In the former, the spring presses the member *P* forward jamming the one half of the disks against the other half, this jamming action transmitting the power. To throw out the clutch, the lever *L* moves backward and pulls with it the casing *M*, this being connected to the member *P* draws the latter out and away from the disks. The natural spring of the latter then asserts itself, and they free themselves.

In Fig. 102, the disks are of smaller area, but this is more than

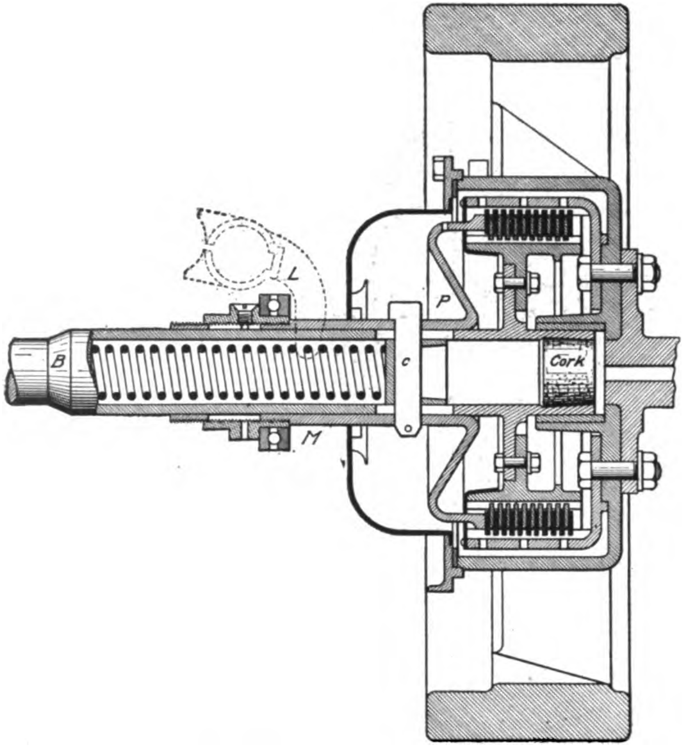


Fig. 101. Panhard Disk Clutch with Spring Fully Enclosed.

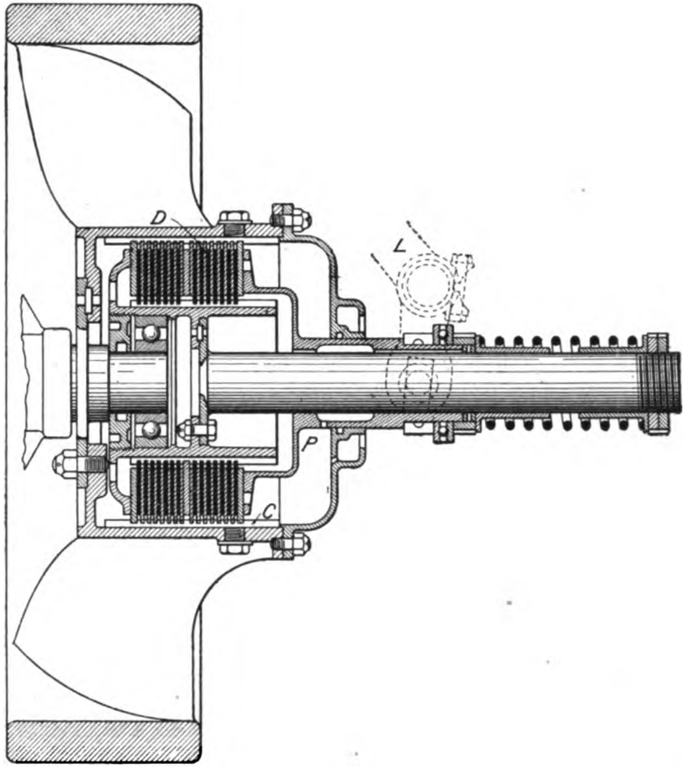


Fig. 102. Westinghouse (French) Disk Clutch with Spring Outside.

made up by the increased number of them, so that the total amount of frictional surface remains the same. *D* shows the series of disks which the spring jams together through the medium of the member *P*. At *C* may be seen one of the keys upon which the movable disks slide. The action of the spring and lever in disengaging the clutch is the same as in the case of Panhard. While these two clutches differ only in minor details, the Chalmers clutch, shown in Fig. 103,

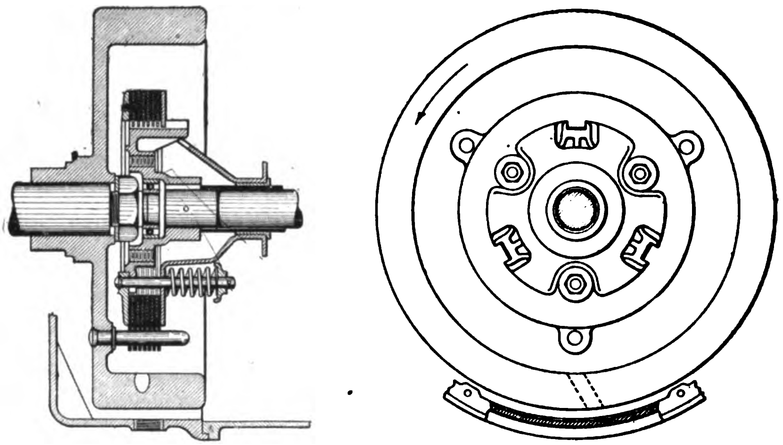


Fig. 103. Chalmers Flat-Disk Clutch.
Chalmers Motor Car Company, Detroit, Mich.

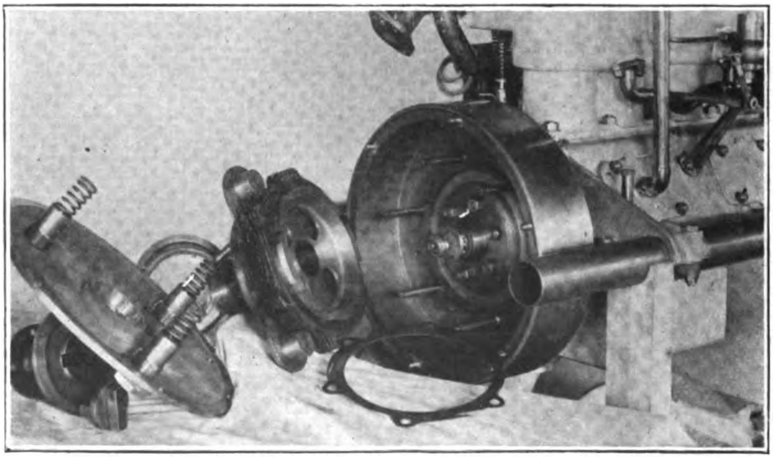


Fig. 104. Lozier Disk Clutch Dissembled.
Lozier Motor Company, Plattsburg, N. Y.

is radically different. There are many plates, but they are plain flat disks, notched for the holding keys, half on the outer periphery, and the other half on the inner edge.

In the Lozier form, on the other hand, the plates are formed. This is a method which is very good but correspondingly expensive, consequently it cannot be resorted to except upon cars of the highest grade, selling at very high prices. Fig. 104 shows the Lozier clutch as used on their Little Six, 45-horse-power car.

Differing somewhat from the others is the form of multiple disk clutch as used on the Scotch Argyll cars, Fig. 105. In this, it will be noticed that the disks are slightly less in number and of diameter to compensate for the loss therein. The whole interior of the flywheel is used up for the clutch, no attempt being made to utilize the fan spokes for cooling purposes.

Increase in Power Transmitted by Surfaces not Plane. In the way of increasing the amount of power transmitted by the clutch for a given diameter, the same result is obtained either by increasing the number of plates and with it the amount of friction surface, or by altering the form of the surface. Several methods of doing this have been utilized, notably on the other side of the water. Thus, the French car, *Ours*, uses the clutch shown in section in Fig. 106. The disks of this clutch have a flat outer portion, and a conical inner portion, only the latter taking part in the transmission of power. In the disk form, then, with the disk economy of space, there are the advantages of the cone clutch, and the additive gain of running in a bath of oil.

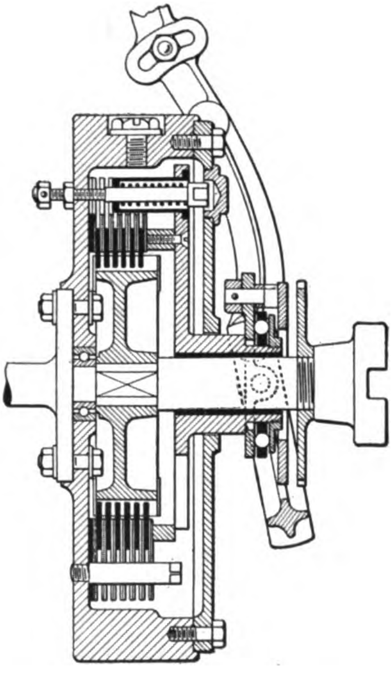


Fig. 105. Argyll (Scotch) Disk Clutch.

Another form utilizing this principle, and one that is more widely used, is that known as the *Hele-Shaw,* so named from its inventor, the famous Englishman of science, Dr. H. S. Hele-Shaw. This is essentially a flat disk, as shown at *A*, Fig. 107, with a ridge *B* at about the middle of the friction surface, this ridge consisting of a portion of the surface which has been obtruded during the stamping process, in such a way as to leave the surface of the ridge in the form of an angle of small size. The angle used is 35 degrees, and this value has been determined upon experimentally as the best. Fig. 107 shows a cross-section through an assembled clutch which reveals the clutch angle very plainly. In use, the ridges nest, one on top of the other; and in the extreme act of clutching, not only the flat surfaces but both sides of the ridge are in contact with the next plate. Thus, not only is the surface for

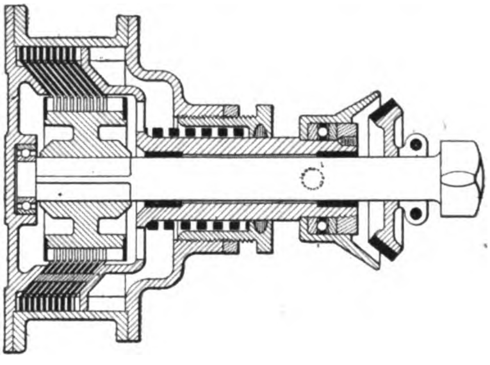


Fig. 106. Ours (French) Combination Cone and Disk Clutch.

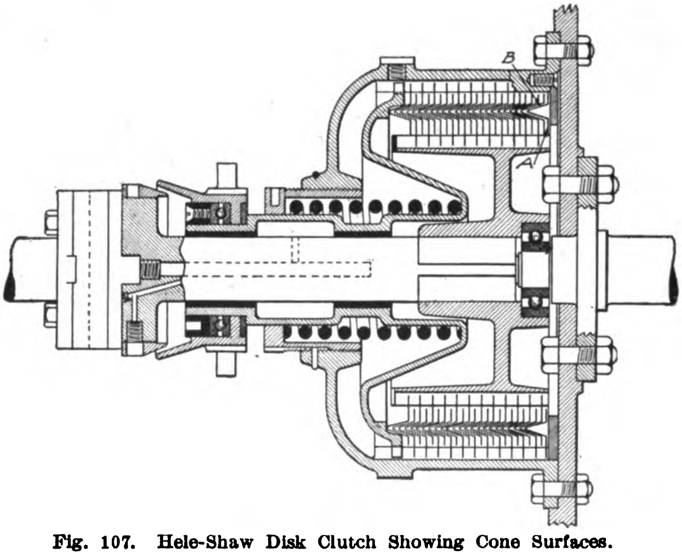


Fig. 107. Hele-Shaw Disk Clutch Showing Cone Surfaces.

a given diameter increased, but the wedge shape is also taken advantage of. Smaller views of the single disks and of the complete clutch, dissembled to make plain its simplicity, are shown in Fig. 108 and Fig. 109.

A brief mention of the method pursued in the design of flat disk clutches will not be out of place. Consider the disk to be used

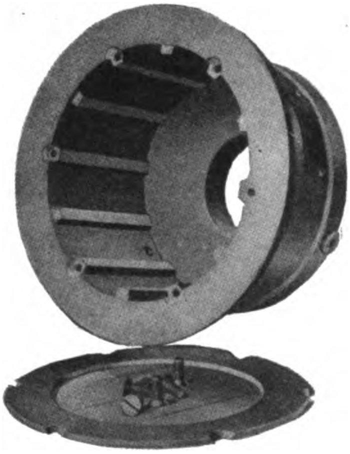


Fig. 108.

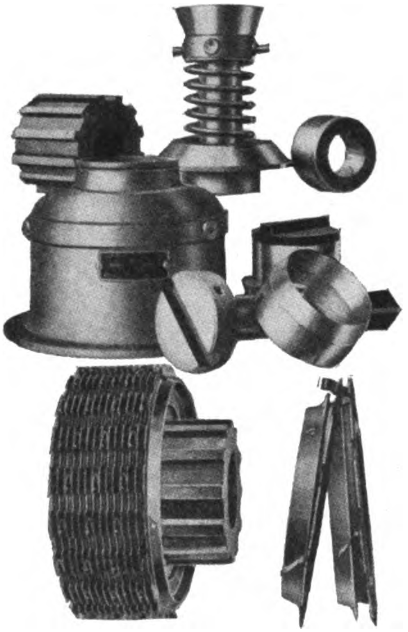


Fig. 109.

Dissembled Hele-Shaw Clutch.

as an annular ring having an internal radius r_1, and external radius r_2. If f is the coefficient of friction, n the number of disks, and p the specific pressure normal to the friction surfaces as distinguished from the spring pressure, then by certain theoretical considerations involving integral calculus, it is found that the moment M of the clutch around the center will be as follows:

$$M, \text{total} = \frac{pf\pi(n-1)}{18}(r_2^3 - r_1^3) \text{ in foot pounds}$$

In use the factor p is found first, by figuring the area of the whole surface and dividing the spring pressure by it, thus

$$\text{Area} = \pi\,(r_2^2 - r_1^2)$$

and the specific pressure is

$$p = \frac{\text{spring pressure}}{(r_2^2 - r_1^2)}$$

Knowing the material, the coefficient of friction is known, and therefore everything is known but the number of plates and their size. By trial the size may be selected, from which the number is easily figured using the above formulæ. Care should be taken in their use to add 1 when the number of plates comes out with a decimal or fractional quantity. In the use of a formula like the preceding one, it is always assumed that the power is known at some specific speed. This being the case, the total torque, which is divided by the total moment to find the number of the plates to use, is

$$T,\text{ total} = \frac{H\,P \times 33{,}000}{2\,\pi \times \text{speed}}$$

Hydraulic Clutches. All of the methods of engaging and disengaging the engine at will, as discussed before, have been of a mechanical nature. The hydraulic clutch, on the other hand, partakes more of the fluid nature, although semi-mechanical, *i. e.*, operated by mechanical means. Ordinarily it is in the nature of a pump with a by-pass, the pump working at ordinary speeds to force the heavy liquid, usually glycerine, through the by-pass. To clutch up tightly, however, the by-pass is closed and the liquid being unable to circulate while the pump continues to operate, the whole device is rotated as a unit. In this case it operates just as any other clutch; but due to the sluggish action of the fluid it is slower to respond. Then, too, there is always present the grave question of leakage, since the smallest leak puts the

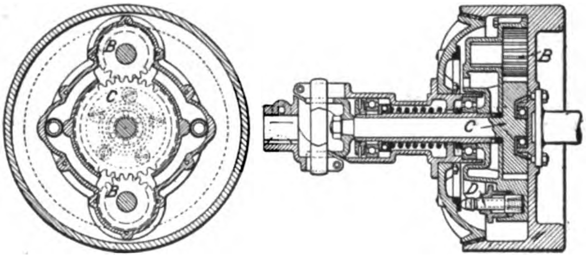


Fig. 110. Stilson Hydraulic Clutch.
Stilson Car Company, Pittsfield, Mass.

clutch entirely out of use. These disadvantages, together with the necessary complications, have retarded the development of the hydraulic form so that there are few of them in use today. In the clutch shown in Fig. 110, a spider is fast to the engine shaft and carries two spur gears *B B*. These are constantly in mesh with *C* which is fast to the driven shaft. The space surrounding these gears is filled with oil, which is pumped around by the rotation of the gears. Several valves, one of which is shown at *D*, allow the oil to circulate freely. Under these circumstances, the pinions on the crank shaft run around the gear on the driven shaft and transmit no motion to the latter. These valves are held open by springs, but by the operation of the foot pedal, a cone is brought forward which presses against the heads of the valves, closing them. Partly closed, the pinions drive the gear slowly because of the resistance which the liquid offers, and when wholly closed, the transmission shaft is driven at full speed with very little loss since the fluid is not very compressible. This clutch, made by the Stilson Motor Car Company, Pittsfield, Mass., was designed for the car known to the trade as the *Stilson Six*.

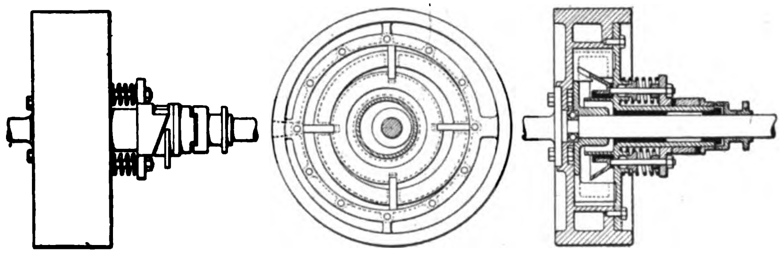


Fig. 111. Pambla Hydraulic Clutch.
North Chicago Machine Works, North Chicago.

Another clutch designed with the same idea, but worked out in a far different manner is that of the North Chicago Machine Company, North Chicago, Ill., and shown in Fig. 111. This clutch is more complicated and has many more parts than the Stilson clutch, but has the advantage of having seen more severe trials and more actual service. It acts as does the Stilson, oil normally passing through passages when the clutch is out, but when prevented from passing, the whole mechanism turns as a unit. The prevention of the liquid passing is accomplished by an eccentric device not very different from a vane type of water pump, the method of throwing it into and out of engagement being very complicated. Fig. 111 shows all of the parts and a study of it will reveal the complete action.

Magnetic Clutch. All of the foregoing clutches present in one form or another very complicated devices for freeing the transmission shaft from the engine shaft, but the magnetic clutch is a device which has simplicity for its foremost argument. The magnetic clutch, or, as the makers prefer to call it, the *magnetic accelerator*, as shown in Fig. 112, is the product of the Cutler-Hammer Electric Company, Milwaukee, Wis. It consists primarily of three parts: the field, usually in the form of a ring, the armature *A* always of ring shape, and the oil casing *C* shaped to accommodate the other parts, its function being that of a cover simply. The armature *A* is a simple cast-iron plate of rectangular section adapted to be drawn into engagement with the field when the latter is energized.

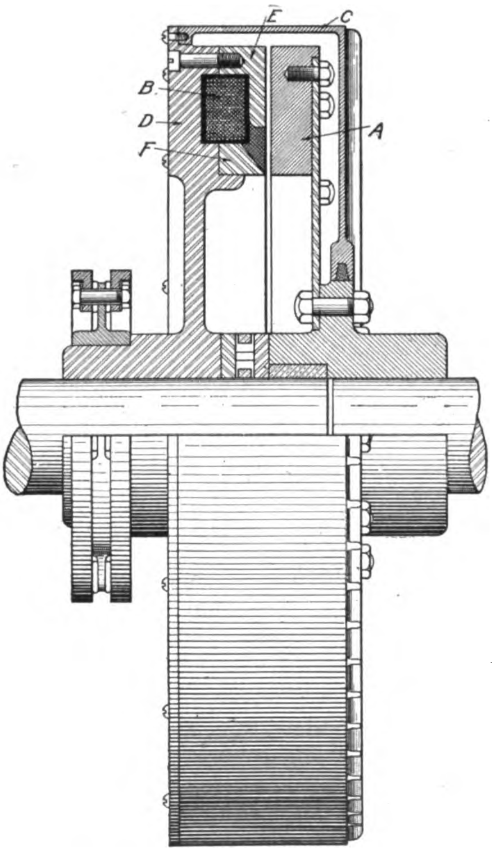


Fig. 112. Section of Cutler-Hammer Magnetic Clutch.
Cutler-Hammer Electric Company, Milwaukee, Wis.

The field, on the other hand, is made up of the back plate *D*, the inner *E* and outer *F* field rings, the magnetizing coil *B*, and the contact rings (not shown). In operation, the accelerator is energized by closing the electrical circuit which sends a current through the field *B*. This magnetism attracts the armature *A* which then moves laterally (to the left), closing the very small gap between the two. The oil in which the whole clutch works prevents it from taking hold suddenly, or gripping, but as this oil film on the two surfaces is gradually squeezed out, the clutch as gradually takes hold. The result is the smooth, easy start so much desired with any form of clutch. A very recent car built in France—the Ampere—uses this construction exclusively, the master clutch being dispensed with in favor of an individual clutch transmission, the clutches being magnetically operated as just described. In addition, the differential is dispensed with, and in its place is used a pair of magnetic clutches, one for each wheel. The differential action is obtained on curves by decreasing the current to the clutch on the inner wheel up to a certain point at which it is cut off entirely. This gradual reduction and cutting off of the current is accomplished automatically by the movement of the steering wheel, so that the driver does not bother about it any more than on any other car.

TRANSMISSION

Primarily the clutch is used to allow the use of change-speed gearing; or, stated in the reverse way, the form of the transmission determines whether a clutch must be used or not, there being cases in which it is not used. Thus, where the frictional form of transmission is used, no clutch is necessary, the frictional disks acting as a clutch and rendering another one superfluous. So, too, with the form of transmission known as the *planetary gear*, no master clutch is needed.

On the other hand, the reverse of this does not always hold. Any form of clutch may be used with the various other forms of transmission, as the sliding gear; in fact, in actual practice every known kind of a clutch will be found coupled with the sliding gear transmission.

Broadly considered, there are five classes into which all transmissions may be placed. In cases where the use of any one of these forms eliminates the final drive, this from its very nature does not alter the facts, but simply calls for a different and more detailed treatment. The five classes are:

1. 'Sliding Gear
   - Selective
   - Progressive
   - Semi-selective
2. Individual clutch

3. Planetary or epicyclic
4. Friction disk
   - Four spurs
   - Three spurs
   - Two spurs
   - Four bevels
   - Three bevels
   - Two bevels
   - One bevel and one spur
5. Miscellaneous
   - Belt and cables
   - Hydraulic
   - Electric
   - Combinations of two or more of the others

Sliding Gear. In the first class the three subdivisions are not very closely marked but blend somewhat into one another; at least, the first and third do, and these with the second to a lesser extent. The only real difference among the three is the method of operation, the three being named each after its own mode of gear shifting. Thus, in a selective gear set, it is possible to "select" any one speed and change directly into it without going through any other. So, too, in the progressive form of transmission the act of changing gears is a "progressive" one, from the lowest up to the highest, and *vice versâ*.

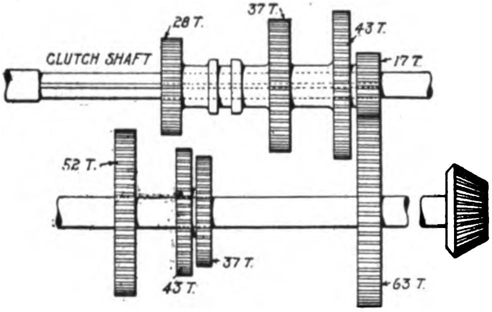
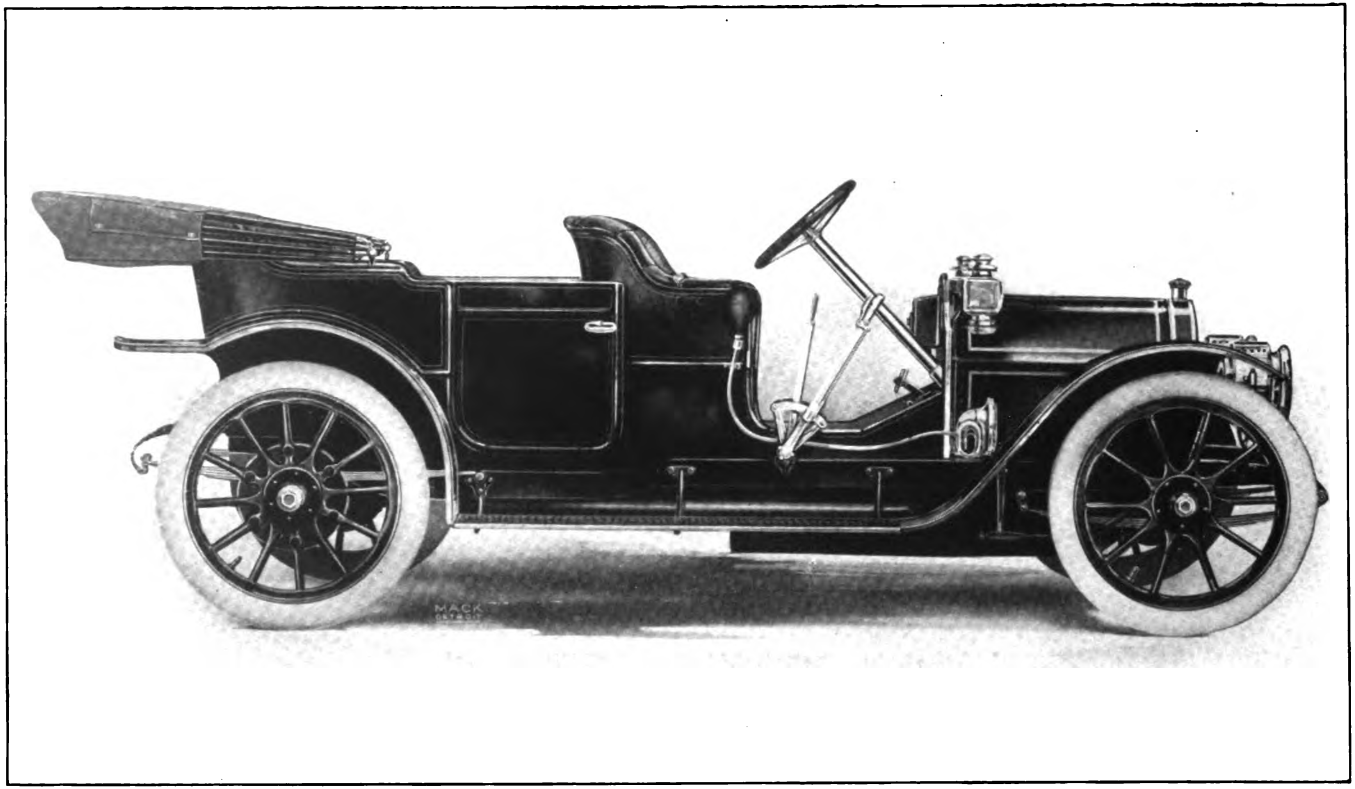


Fig. 113. Panhard (French) 22-H. P. Progressive Transmission.

This leads to a number of bothersome occurrences; thus, in stopping it is necessary to gear down through all of the higher speeds into low. If this is not done, when it is next desired to start the car it will be necessary to start the engine, throw in the clutch, drop from the gear in mesh to the next lower, from that to the next, and so on down to low, throwing the clutch out and in for each change of speed. When this is reached, the car may be started. After starting, it is then necessary in order to obtain any measurable speed with the car, to change back up the list, from low to second, from



CHALMERS "THIRTY" TOURING CAR
The Chalmers Motor Car Co., Detroit, Mich.

second to third, and so forth. In this way the progressive gear is disadvantageous, since its use means much gear shifting; but, on the other hand, the shifting is very easy for the novice to learn, as it is a continuous process, all in one direction to increase speed and all in the other direction to decrease.

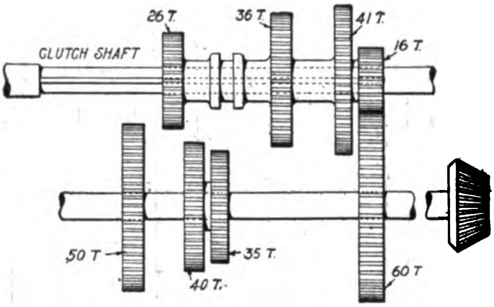


Fig. 114. Panhard 32-H. P. Progressive Transmission.

Selective Type. With the selective method of changing gears, this prolonged process is not needful, as it is possible to change at once to the desired gear without passing through any other. Of course, the car will not start on the high gear any more than in the other case, but shifting into low for starting purposes is but a single action accomplished quicker than it can be told. So, too, when the car has been started, it can be allowed to attain quite a fair speed and the change to high made at once without going through second and the other gears.

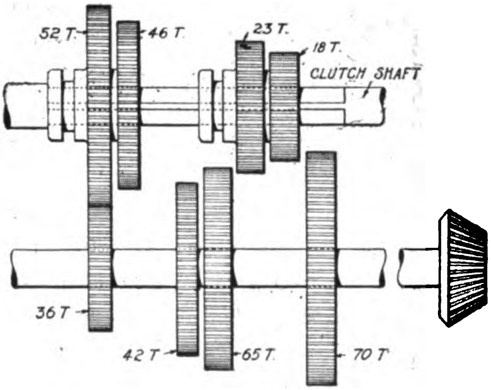


Fig. 115. Mercedes (German) 22-H. P. Selective Transmission.

Progressive Type. Progressive gears, often called after the originator of the system, *Panhard* gears, are said to operate on the Panhard system. In Fig. 113 is shown the Panhard transmission for a car of 22 horse-power, and in Fig. 114, the Panhard gears for a car powered with a 110 mm. by 140 mm. engine rated at 32 horse-power. Both of these are four-speed transmission and to show graphically one big disanvantage claimed against this form as in favor of the selectively operated gears, Fig. 115 and Fig. 116 are given. These represent respectively the four-speed transmission used in the Mercedes cars of approximately equal power to the two Panhards just described; viz, four cylinders, 80 mm. by 110 mm. for the first figure, and four cylinders, 100 mm. by 125 mm. for the latter. The difference in the overall length of the two is immediately noticeable, yet the only other difference is that the Panhards are operated progressively and the German cars selectively.

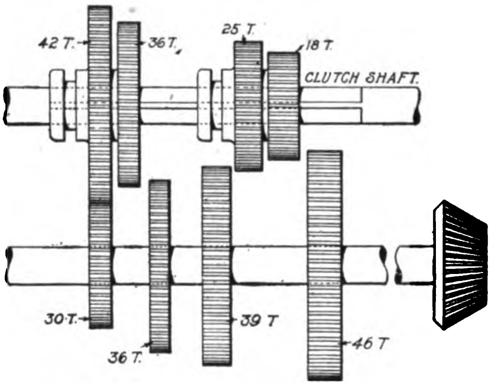


Fig. 116. Mercedes 32-H. P. Selective Transmission.

Panhard is not alone in his belief that the progressive method of shifting is *the* method, as is shown in the use of the same form by a number of the best of American manufacturers. Thus, the gear box shown in Fig. 117 is that used in the Royal cars, made by the Royal Motor Car Company, Cleveland, Ohio, and works progressively. In this gearset three speeds are secured, the reverse being brought into play by dropping another and a separate gear into mesh with two of the sliding train when the same is in an otherwise neutral position.

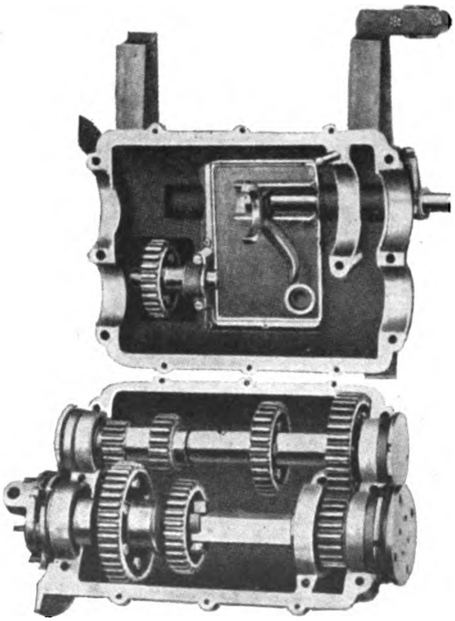


Fig. 117. Royal Motor Car Company Progressive Gearset.

Stevens-Duryea is another prominent advocate of progression. Fig. 118 is the Stevens small gear box, and Fig. 119 shows how the whole outfit looks when partly dissembled. The first figure shows the single

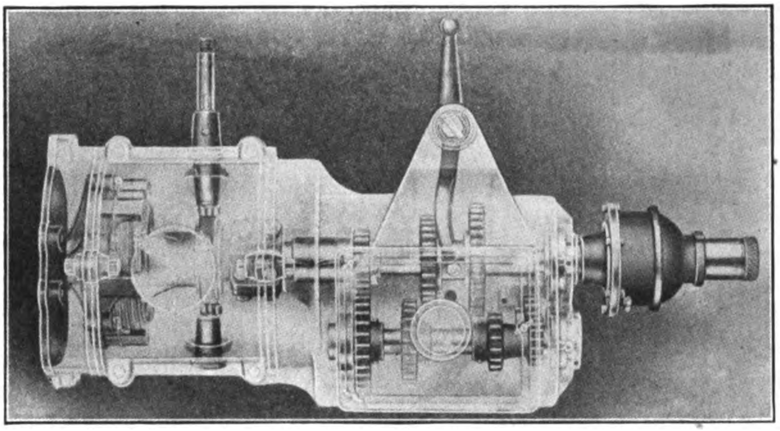


Fig. 118. Stevens-Duryea Progressive Gears.

shifting unit attached to the shifting lever. In the second illustration, the sliding member just spoken of is seen at *H*9, while *H*8 indicates a pair of the gears, the smaller one of the two carrying the four-jawed clutch into which the corresponding clutch on the slider moves to make the direct drive on high speed. Fig. 120 illustrates

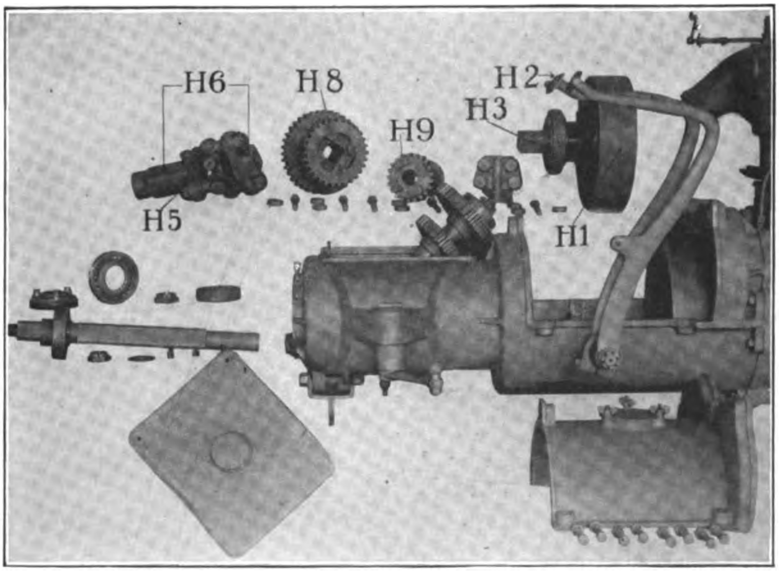


Fig. 119. Stevens-Duryea Gear Box Showing Parts.

the extent to which the matter of simplification may be carried with this form. In Fig. 121, on the other hand, is seen an excellent example of a well worked-out four-speed, semi-selective gear.

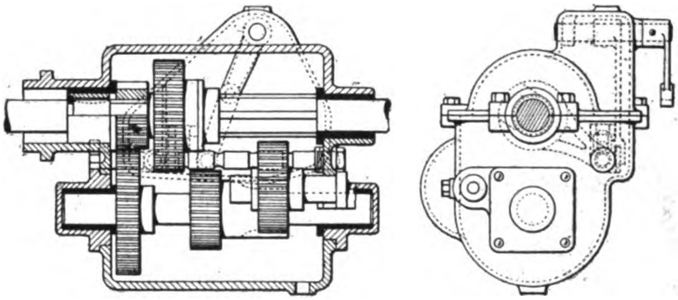


Fig. 120. Simplicity the Keynote of Progressive Transmission.

Semi-Selective Type. Fig. 122 shows the three-speed and reverse transmission of the Winton automobiles, made by the Winton Motor Carriage Company, Cleveland, Ohio. The operation of this is as follows: there are two sliding members—the single gear *A* and the double gear *B*. The former is moved forward and back by the sliding of the rod *C* which carries the lever *G*, the latter being connected to the gear in question. Gear *B* is similarly actuated by lever *F* and rod *D*. When rod *D* is moved forward (to the right) as far

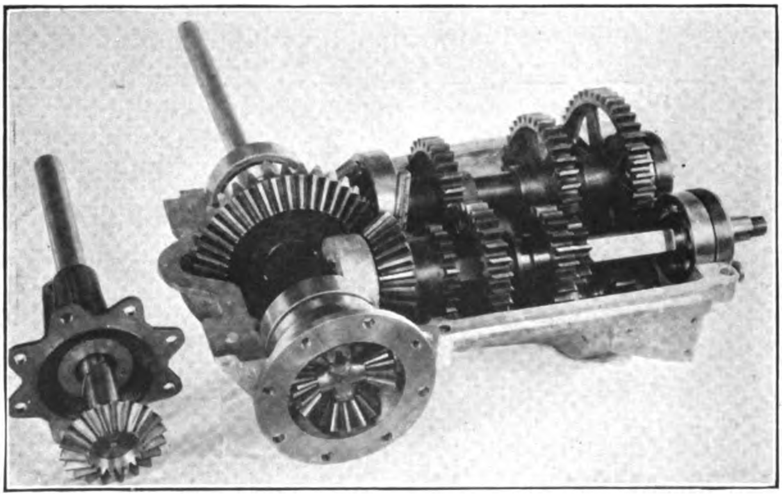


Fig. 121. Chadwick's Mercedes Type of Transmission.

as possible, the gear cut on its forward face meshes with the internal gear cut inside of gear *L*. The former being keyed to the shaft, while the latter is driven from the engine, this gives the direct drive, and is the highest speed. Moving this same rod *D* back far enough meshes gear *B* with gear *J;* the drive is then *L* to *K*, *J* to *B*. When rod *C* is advanced slightly from the position shown, it engages gear *A* with gear *I*, when the drive is *L* to *K*, *I* to *A*. This is the third or slowest speed. Moving this rod as far back as possible brings gear *A* opposite gear *H*, but in mesh with another gear not shown, which is in mesh with *H*. This, then, gives the reverse speed.

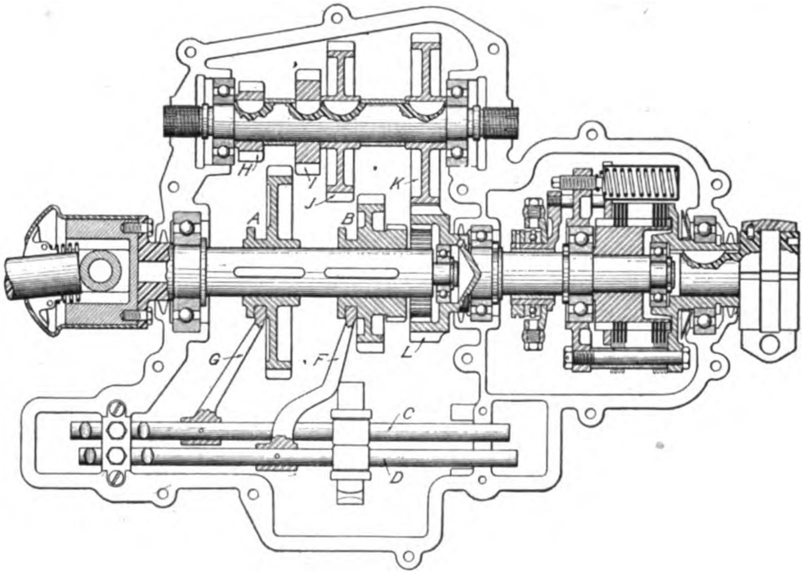


Fig. 122. Winton Three-Speed Selective Transmission.
Winton Motor Car Company, Cleveland, Ohio.

Slightly different from this is the transmission of the 15-30 Stearns—made by the F. B. Stearns Motor Company, Cleveland, Ohio—due to the fact that in the latter case, the transmission is made a unit with the rear axle and differential. Of the two views shown in Fig. 123, the upper one is a section in a vertical plane, while the lower is a section in a horizontal plane. In the upper view, it will be noticed that the two sliding members *A* and *B* are located on different shafts, instead of on the same shaft as in the previous case. It is also apparent that both slide, not on round shafts held in place by keys, but on squared shafts as at *C* and *D*. The sliding member *B* carries the gear *J*, and at its front end an internal gear *M*. This meshes with a similar gear extension on gear *E*, giving direct drive which is also the high speed. Sliding backward so as to mesh this with gear *G*, gives second speed, through *E*, *F*, *G*, and *J*. When the other sliding gear *A* is moved back so that *I* meshes with *K*, the third speed is obtained through *E*, *F*, *I*, and *K*. When moved back so that gear *H* meshes with *L*, another gear *N* on the same shaft meshing with *K* gives the reverse, thus, *E*, *F*, *H*, *L*, *N*, and *K*.

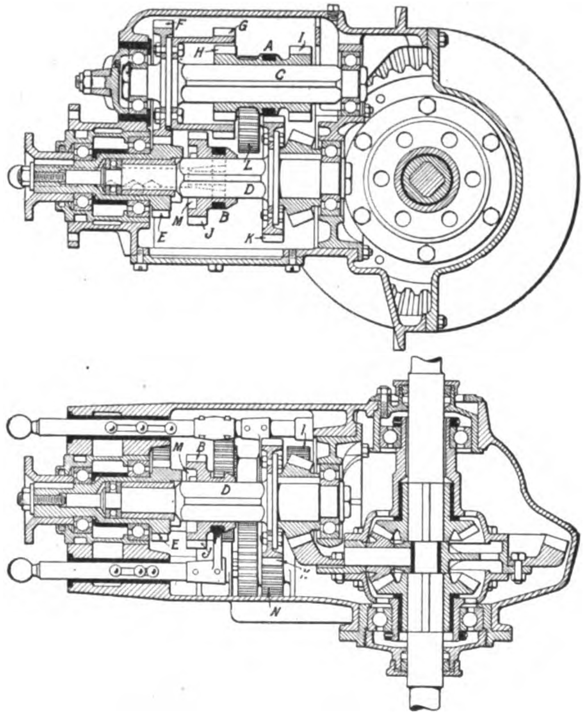


Fig. 123. Stearns Compact Transmission for 15–30-H. P. Models.

To separate the differential case and the gear box is apparently a simplification, as Fig. 124 shows when compared with Fig. 125. The former is the transmission of the Pullman car made by the Pullman Motor Car Company, York, Pa. In this also, are two sliding members, both on the same shaft. One slides forward for high speed, direct drive, and backward for second speed, while the other has three positions, for third, fourth, and reverse speeds. The first is obtained by drawing to the right so as to mesh with the third gear on the lay shaft, while the last gear on the same shaft gives slow or fourth speed. Continuing the backward movement brings the larger gear of the sliding pair into mesh with a gear on another shaft, seen below the lay shaft, which results in reverse.

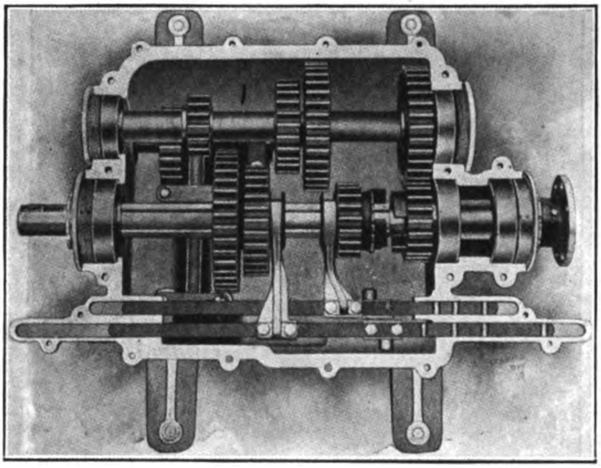


Fig. 124. Pullman Four-Speed Selective Transmission.

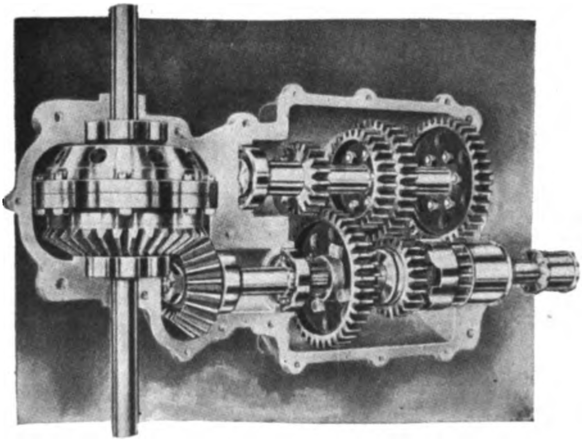


Fig. 125. Tincher Selective Transmission.

In Fig. 125 is shown a Mercedes type of gear for a chain-driven car, this being a very high-grade piece of mechanism made from the strongest and best material obtainable and finished in the finest manner. The view is such as to preclude the possibility of explaining the shifting mechanism, but this is about the same as in the preceding example.

A great difference between two products from the shop of one maker is often noticeable. Thus, Fig. 126 shows the four-speed gear box of the Stearns 30–60 and 45–90 horse-power models. Comparing it with Fig. 123 the difference is at once seen. In operation, however, this is like the transmission just described.

Fig. 127 shows only the gears, shafts, and bearings of the three-speed Knox transmission which is used in all the high-powered touring cars made by the Knox Automobile Company, Springfield, Mass.

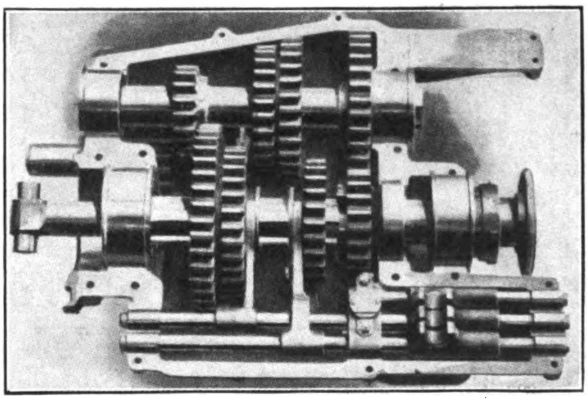


Fig. 126. Stearns Four-Speed, Selective Transmission.

The short, stubby shafts of very wide, long-wearing faces will be noticed, as will also the idler gear which serves to reverse the direction of the drive. The end to the left is the driving or engine end, while at the right is the driven or rear axle end. In the foreground are shown the double row ball bearings, which not only take the radial load, but carry thrust as well. This is a very simple and well-made transmission.

Just for comparison with the domestic product, the transmission of a famous German car is shown in Fig. 128, this being from the Horch, winner of the Herkomer tour of 1909. High speed is obtained with direct drive by meshing gears *A* and *D*, through a gear not shown, cut in the face of *A*. Second is obtained by the combination *A*, *B*, *C*, and *E*. Third is given by *A*, *B*, *F*, and *G*. Fourth is produced by *A*, *B*, *H*, and *I*, while a still further movement to the right of this second train gives the reverse. Attention is specifically called to the device for throwing the lay shaft out of gear when the high speed is engaged, this resulting in no gears running on the direct drive, that is to say no gears meshing face to face. The result is

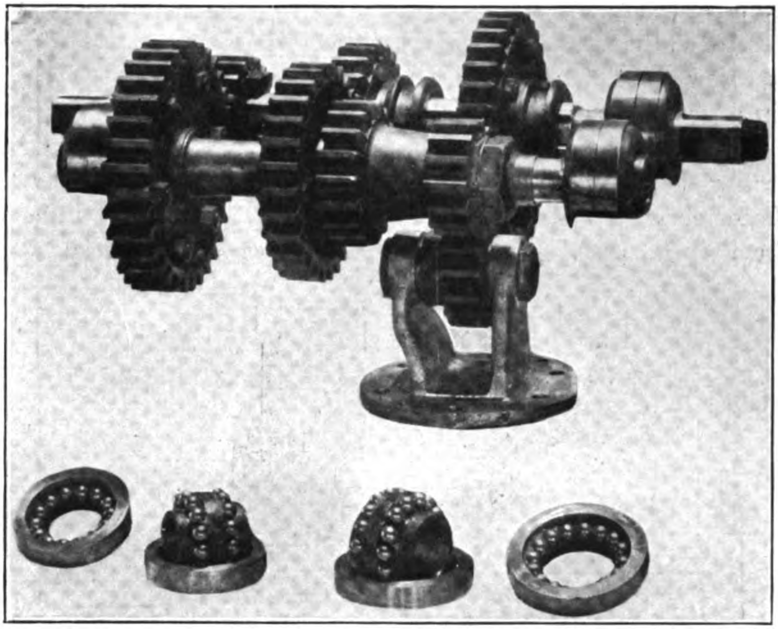


Fig. 127. Gears and Bearings of Three-Speed Knox Transmission.
Knox Automobile Company, Springfield, Mass.

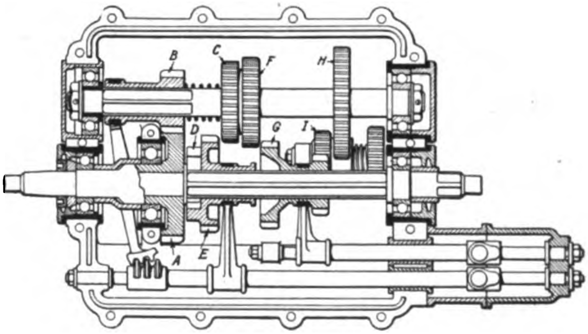


Fig. 128. Horch (German) Selective Transmission.

an absolute lack of gear-box noises on high speed. High speed is effected by the final movement of the shifting rod to the left which actuates the high gear The partial worm engages a sector so pivoted in the middle as to slide the gear *B* to the right, and enough to throw it out of mesh with *A*, when the shaft is moved so as to introduce gear or rather jaw clutch *D* into its mate within *A*.

Another chain-driven car's gear box is shown in Fig. 129, illustrating the Locomobile product made in Bridgeport, Conn. by the Locomobile Company of America. This is not widely different from several previously shown, nor is its operation. Special attention is called to the method of manufacturing the gears. These consist of simple rings of metal, carrying the teeth, as *A*, *B*, and *C*, bolted up to flanges, as *D* and *E*, which are made integral with the shafts. In this way, the cost of the shaft is only slightly increased while that of the gears is reduced to a small fraction of the former cost. Moreover, replacement in case of accident is made much cheaper, and actual work of replacement is also lessened.

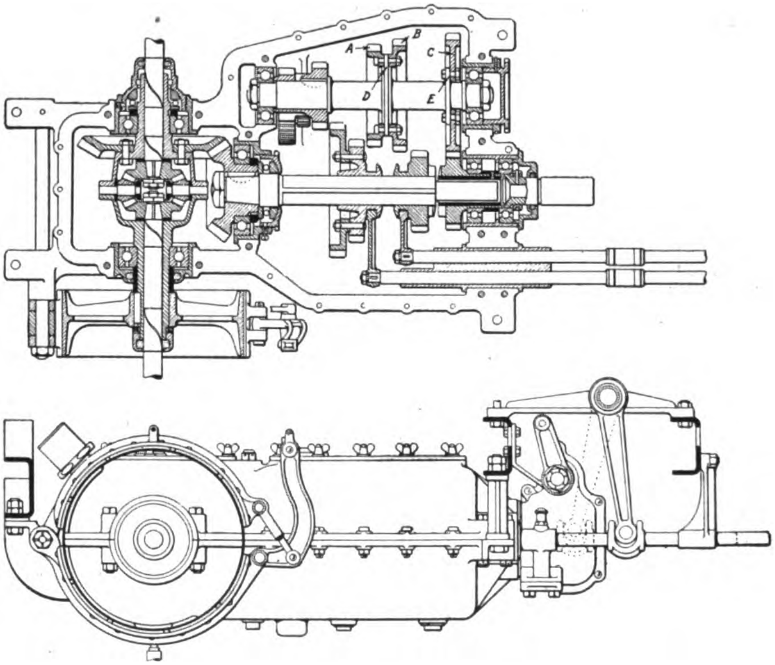


Fig. 129. Gear Box, Differential, and Brake of Chain-Driven Locomobile.

This method of producing gears and shafts for gear boxes is meeting with increased favor.

In all of these transmissions but one reverse is provided, which is a comparatively simple matter. When it comes to railway cars, however, it is necessary to have all speeds operate in both directions, *i. e.*, having as many reverse speeds as forward, and in consequence additional and different gearing is a necessity. In Fig. 130 is shown an example of this, being one of the transmissions used by the Sheffield Car Company, Three Rivers, Mich., in their gasoline-driven railway cars. The driving bevel, faintly seen at *A* instead of driving but one bevel as is usual, drives two, *C* and *D*. Each one of these is free on the shaft, being bushed to reduce wear, but between the two is a sliding member *B* with jaw clutches formed on both faces. This slides on a squared shaft, and the jaw clutches match jaw clutches formed in the inside face of the two driven bevels. When slid to the right, then, *B* engages with jaw clutches in gear *D*, and thus drives it. If then the gear box gives three speeds, all three may drive through this combination, giving the forward speeds. If it

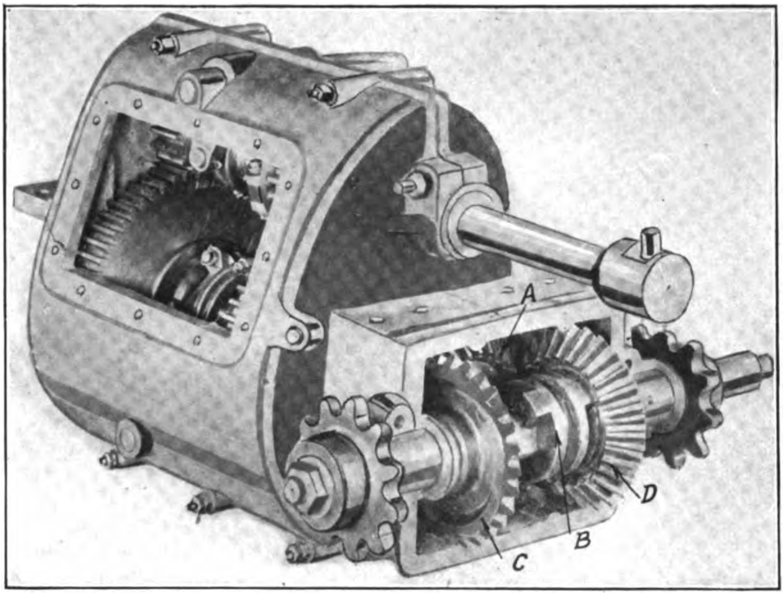


Fig. 130. Form of Gear for Gasoline Railway Car.

is desired to drive in the other direction, the clutch member B is slid out of mesh with D and into mesh with C, thus reversing the direction of motion, and the direction of all speeds.

More than this, there are many possibilities in the placing of the various units. The forward position of the engine has now become universal, but the same cannot be said for the transmission. This unit, on the contrary, is placed in every conceivable position from an integral part of the engine rear end to a part of the rear axle and differential housing. Fig. 131 shows an example of the latter form of placing. This makes a very simple looking form, but such is not always the case, as shown in Fig. 132.

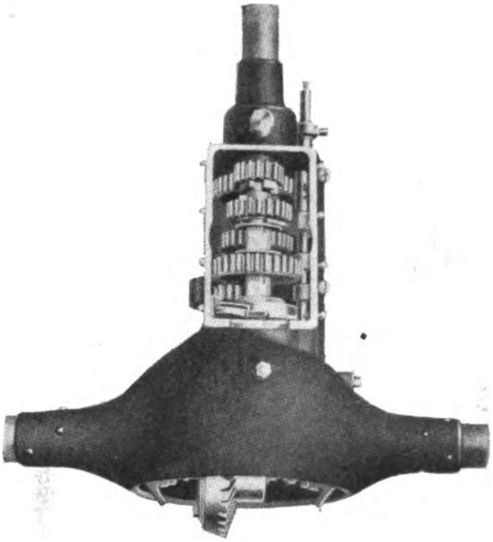


Fig. 131. Transmission Combined with the Differential on the Rear Axle.

Individual Clutch. While the number of adherents to the individual clutch type of transmission is not as great as that of either the progressive or selective types of sliding gear, still it holds its own; and, in fact, as time passes, it gains adherents. In this form, all of the gears are in mesh at all times, and what has been called *the barbarous and unmechanical* method of clashing gears is entirely done away with. The individual clutch type is operated on the selective plan; but otherwise has nothing in common with the latter.

The forms of clutches used vary greatly, as might be expected. The following are in use today: jaw clutches (both two, and multiple jaw); internal-external gears; multiple disk; cone; and friction clutches other than the multiple disk form. One type in which the gears are thrown into engagement by means of internal dogs, the gears being in mesh at all times is shown in Fig. 133. There are four sets of gears, those on the main shaft being keyed or otherwise fixed to the shaft, while the gears on the jack shaft run idle except when the gear shifting lever is moved forward to an engaging position, which movement throws an internal dog up into a slot inside

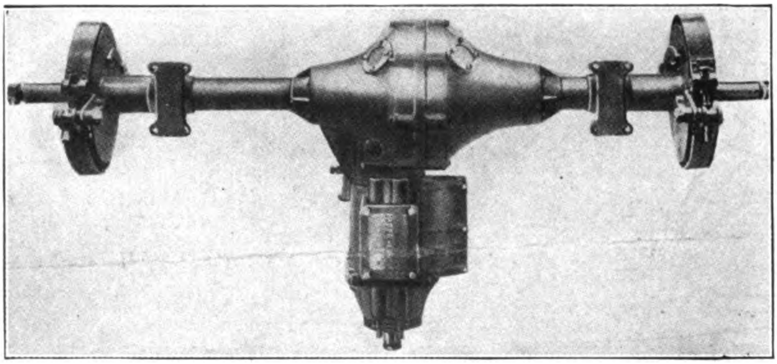


Fig. 132. Rider-Lewis Transmission and Differential.

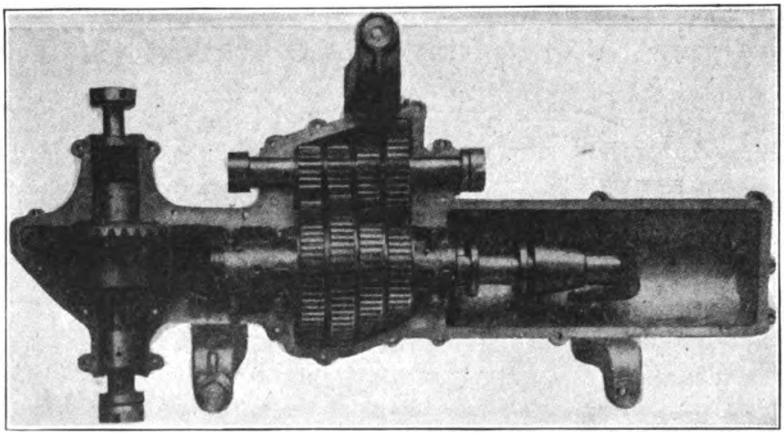


Fig. 133. Berkshire Individual Type of Change Gear.

of the gear. This makes the gear one with the shaft, and so, the power is transmitted. The dogs in the latest form of this transmission take the form of hardened and ground steel balls. This type of gear is made by the Berkshire Autocar Company, Pittsfield, Mass., for their four-cylinder touring car.

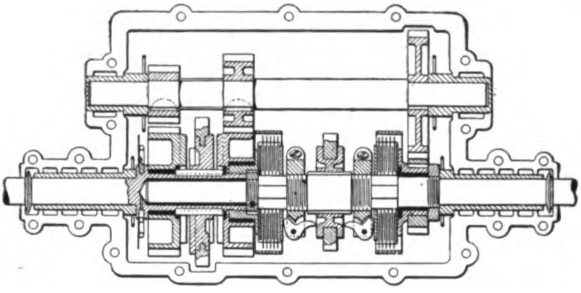


Fig. 134. Welch Individual Disk Clutch Transmission.
Welch Motor Car Company, Pontiac, Mich.

An equally interesting but very similar type in principle is that shown in Fig. 134, the transmission formerly used by the Welch Motor Car Company, Pontiac, Mich. In this, disk clutches are used to engage the various gears as desired. Not very different is the gearset used at one time on the Oxford car, Fig. 135. It affords but two forward speeds and a reverse. This number of speeds has doubtless held back the general use of the individual clutch type of transmission, since, with a large number of speeds, the gear box becomes both bulky and heavy.

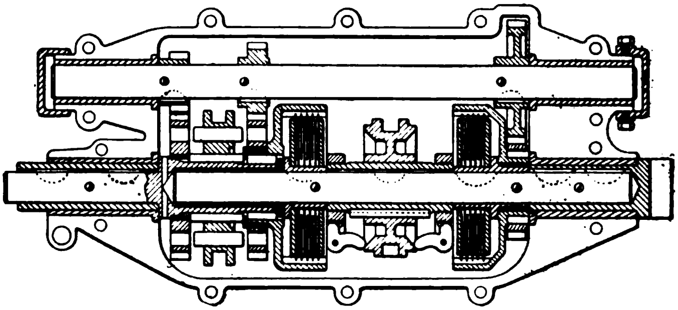


Fig. 135. Oxford Disk Clutch.

While the advocates of disks for this use are numerous, the other devices do not lack for friends. Fig. 136 shows a form that, on the Haynes-Apperson cars, attained much popularity. In it, the clutching action is produced by means of contracting bands, working on large diameter drums, the latter being keyed each to its own gear. The full explanation of the action is as follows: The engine drives the shaft *A*, upon which are mounted the gears *C*, *D*, *E*, and *F*. These are all permanently fixed to the shaft and rotate with it. Upon the driven shaft *B* are mounted another equal number of gears, meshing with the former, but all loose upon the shaft, so as to spin idly. Bolted to each one of the latter is a large drum, while close to it is a framing upon which is mounted a contracting band. The latter framing is keyed to the shaft, so that when it is rotated the shaft must turn with it. In action then, when any speed was desired, the band was contracted until it seized the drum bolted to the gear which gave that speed, when the gear, drum, band, and framing all turned as a single piece. As the gear was positively driven from the engine and the framing was keyed to the lay shaft, the desired reduction of speed resulted.

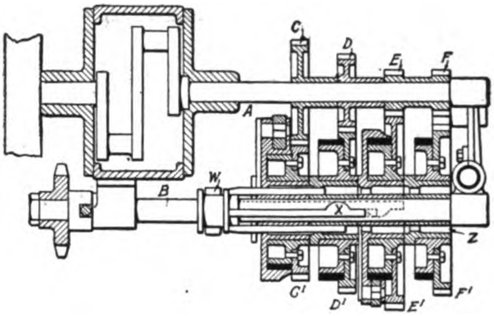


Fig. 136. Early Form of Haynes Clutch Gearset.

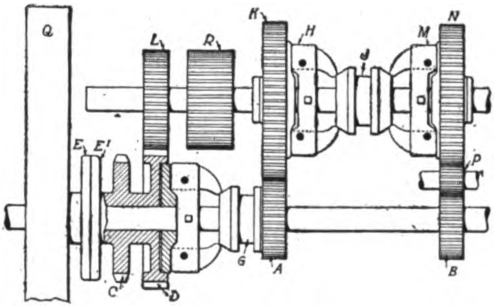


Fig. 137. Early Form of Winton Individual Clutch Transmission.

Winton long advocated the individual clutch gear, his clutch taking the form of a single disk, pressed against the gear by means of numerous fingers, Fig. 137. A conical sliding piece *G*, or *J*, expanded the fingers pivoted on *M* and *H* so that they pressed against the disk within the gears *D*, *K*, or *N*. This form is seen in Fig. 137. Many of these date back several years, but the gear illustrated in Fig. 138

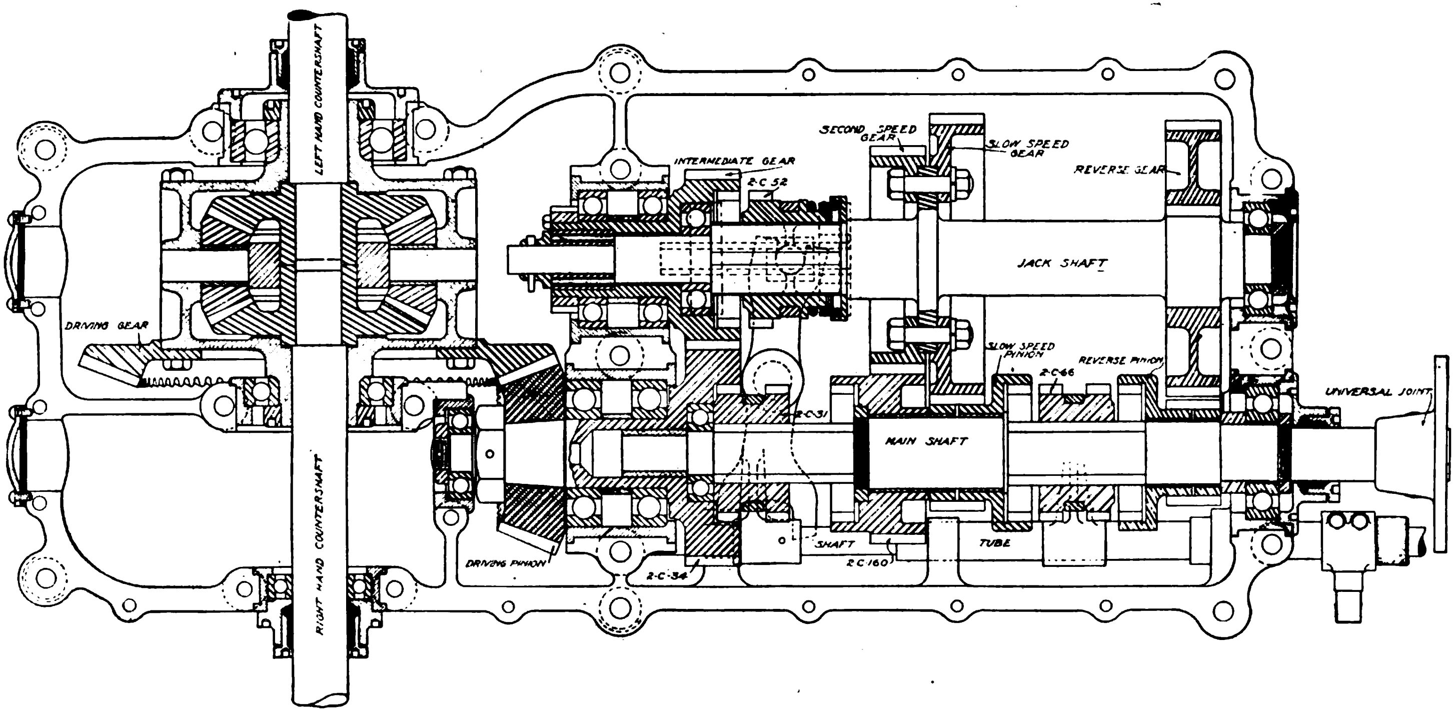
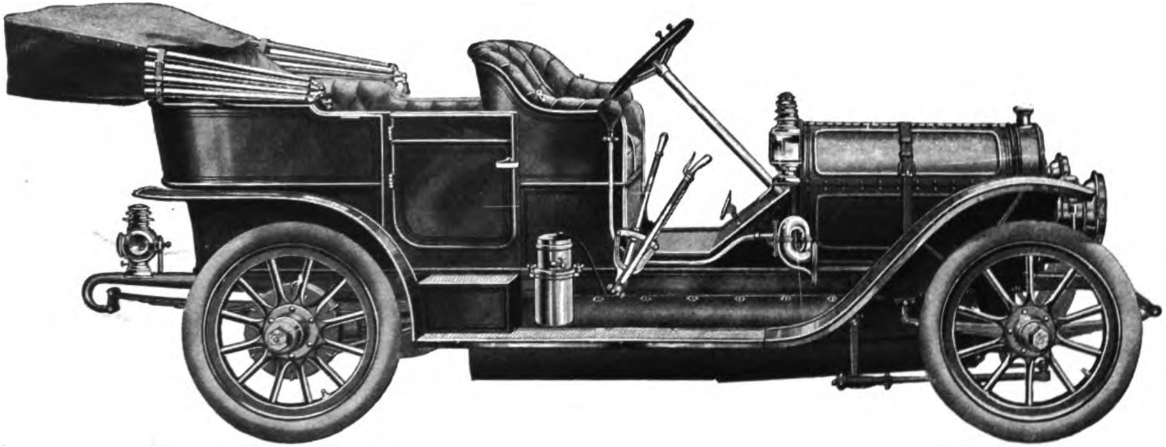


Fig. 138. Mack Commercial Car Individual Clutch Type of Gear Box.
Mack Brothers Motor Car Company, Allentown, Pa.



POPE-HARTFORD, MODEL S, TOURING CAR
Pope Manufacturing Co., Hartford, Conn.

is a very up-to-date one, being used today on all of the cars put out by the Mack Brothers Motor Car Company, Allentown, Pa. More than this, it is used for the most severe service possible, viz, for commercial vehicles, which constitute the whole output of this firm.

As the drawing shows, the principle upon which it works is that of the internal-external gear. The gears which transmit the power are always in mesh. Each one of these is bushed and runs idly upon the main shaft. Contained within each and an integral part, is an internal gear of twenty-four teeth. Sliding on the squared shaft are four twenty-four teeth gears, these being specially built for easy engaging with the internally cut gears. In operation, any one may be slid into its corresponding gear without going through any other. These being very small and light, have no inertia as would a large, heavy gear with as broad a face as is necessary for this severe service. In actual continuous service, this form has proved its worth.

To follow the letters placed on the parts of this gear, high speed is obtained by sliding the piece 2–*C*–31 forward into gear 2–*C*–34, which action swings the piece shown dotted beneath, so as to throw out clutch on the lay shaft 2–*C*–52. On high speed, the two gears locked together are the only ones to turn, all others being idle. The same piece, 2–*C*–31, when slid to the right meshes with the internal gear of the second speed pinion 2–*C*–160. This sliding member slides upon a squared shaft, so the drive is positive. The action of the third or slow speed and reverse are the same as those just described, being produced by the shifting of the clutch member 2–*C*–66. Attention is called to the ball bearings used on this transmission, which are only remarkable when it is remembered that this is a commercial truck transmission. Students of automobile construction will find many interesting constructional details in this illustration which is a reproduction of the manufacturers' working drawing.

Still another similar form uses three cone clutches in the transmission, that for the high speed being augmented by a set of pins or dogs, which, as the clutch gradually takes hold, slip into an equal number of holes in the driven gear. In this way, the two are made as one, which makes slipping impossible, a very important feature on the high gear.

Planetary Gears. The planetary, or epicyclic, form of gearing offers many advantages, but, strange to say, the American people, although inclined towards simplicity and cheapness in combination, will not have it in this form, and, as a consequence, this excellent gear reducing means is fast falling into disrepute. Fig. 139 and Fig. 140 show an exterior and an interior view of the planetary gear as worked out for use on the Rapid commercial cars, built by the Rapid Motor Vehicle Company, Pontiac, Mich. The principle upon which all planetaries work is as follows: Connected to the engine is the first gear of the train. The second is one of a series of several, these being pivoted in a drum which may be held stationary by a brake band. The middle or third in the train, as well as the last or fourth, is connected to another gear, a *driven gear not* a *driver*. Considering but a single rotating train (there usually are three or more), the last-named gears form the fifth and sixth in the whole train. Gears two, three, and four are all of different numbers of teeth, as well as the gears one, five, and six. Holding the band which holds the drum to which the gears are pivoted allows them to rotate around

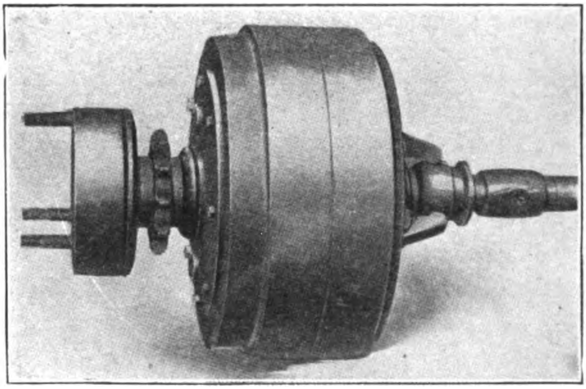


Fig. 139. Assembled Planetary Transmission of the Rapid Company.

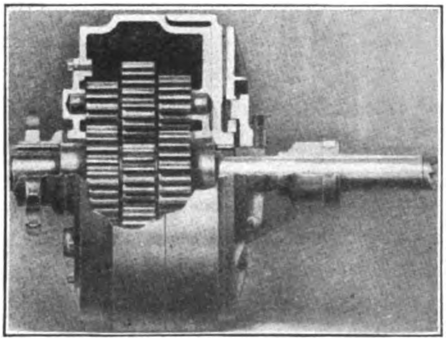


Fig. 140. Partial Section of Rapid Planetary Transmission.

their own axis but not around the main shaft. This form of rotation gives *one* gear reduction.

Holding another band holds another gear stationary and allows the three-gear unit to rotate around the main shaft as an axis, while at the same time it leaves them free to also rotate around their own axis. This produces *another* gear reduction. Another form which is popular in so far as planetary gears are popular, is that in which internal gears are substituted for one set of the planets, from which the device obtained its name. This does not complicate the device any; in fact, the only way in which it makes any change is in the manufacturing cost of the gear, internals costing more than spur gears. In Fig. 141 is seen a form of planetary gear, in which no reverse is provided because the work was such as to call for all speeds in both directions. This necessitated the use of a bevel gear reverse, through which the final drive was taken. As the drawing shows, this simplified the transmission very much. There is the crank-shaft gear *A* near to the flywheel *F*, which gear is in mesh with a series of three

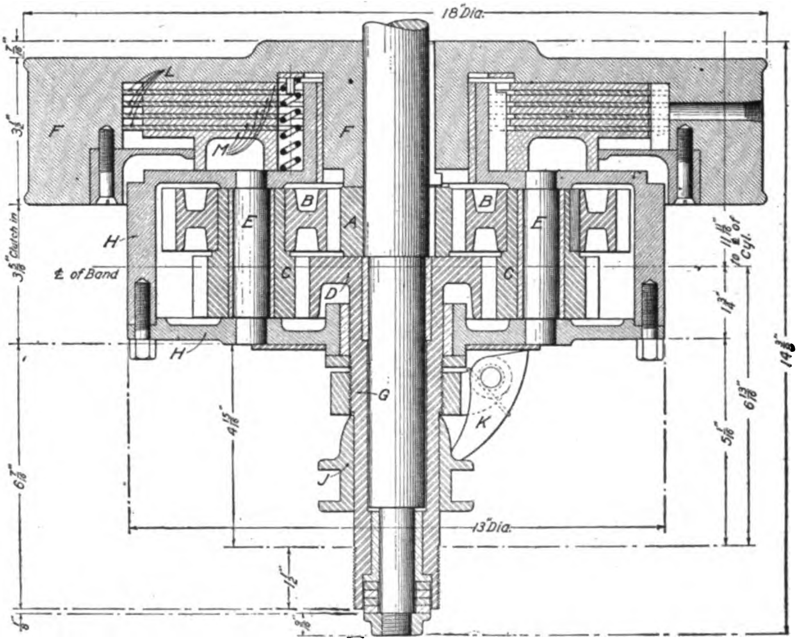


Fig. 141. Two-Speed Planetary for Railway Cars.
Sheffield Car Company, Three Rivers, Mich.

pinions *B B*, two only being shown. The latter are made an integral part with other smaller pinions *C C*, which mesh with another gear *D* fast to the driven shaft *G*. The drum *H* holds the two ends of the shaft on which the planet pinions *B* and *C* rotate. This prevents them from turning about the main or crank-shaft axis *I*, but when the engine is driving them they are forced to rotate on their own axis *E*. The result of this is to drive the final shaft *G* in the reduction ratio of the two pairs of gears *A* to *B* and *C* to *D*. Thus, suppose the gears to be of the following number of teeth, which is not far from the actual case: crank-shaft gear *A*, 18 teeth; larger pinion *B*, 24 teeth; smaller pinion *C*, 15 teeth; final driven gear *D*, 27 teeth. If the crank shaft *I* turns over, say, 1,000 revolutions per minute, the pinion shaft will be turned 1,000 × 18 divided by 24, or 750 revolutions. The smaller pinion also turns over 750 and imparts to the final gear a rotation of 750 × 15 divided by 27, or 417 revolutions per minute. This is the *low speed.*

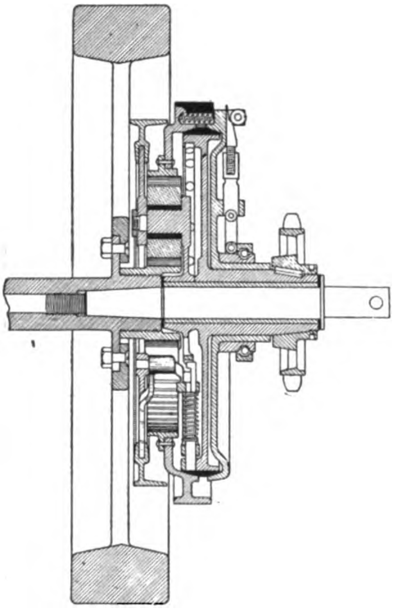


Fig. 142. Duryea Planetary Gear.

Now, to obtain the *high speed* the sliding cone *J* at the left is moved over the expanding levers, which serve to push the whole system of gearing over against the flywheel, the disks *L* and *M* (running in oil) acting as a clutch, which finally takes hold, and the whole mechanism rotates as a unit, at crank-shaft speed.

In Fig. 142 is shown another form of planetary transmission, which at first sight appears different. Upon closer analysis, however, this is found to be exactly like any other planetary transmission in principle, the working out of which differs with every form. This is the Duryea gear, used for many years and with good success on the Duryea carriages.

Fig. 143 illustrates another planetary gear, this one being cut for show purposes. It shows the workings of this kind of gearset very clearly. As before stated, one of the faults of this method of transmitting power is that no more than three speeds, one of them a reverse, can be obtained, without complications which far overshadow their usefulness. So, it has come to be accepted as a fact that the limitation of the planetary is but two speeds. Inventors have worked on the problem, however, not always with failure as their portion. Thus, Fig. 144 shows one solution of the problem. This is called the *F. R. V. semi-planetary transmission* by its inventor, C. R. Radcliffe, of New York City, from the fact that the action is not wholly that of the epicyclic gear, but partakes also of the nature of a sliding gear, *i. e.*, on some speeds, the case rotates, while on others, it is stationary and gears inside are shifted. Although not used very extensively, it is said to be successful.

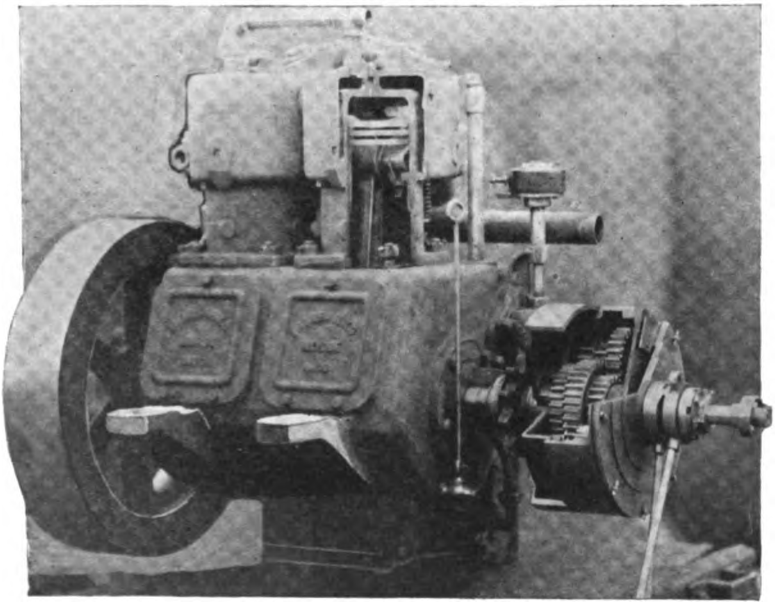


Fig. 143. Section Through Actual Transmission.

Of the same general form but operating differently is the transmission of the Auto Thresher Company, Hutchinson, Kansas. This is shown in Fig. 145 and Fig. 146, the former showing it assembled and ready for use, while in the latter it is drawn out to display the component parts. It was developed for use primarily on traction engines, and being proportioned for such heavy, rough work should not be compared with other transmission of the same class designed and built to be used on lighter and more dainty automobiles.

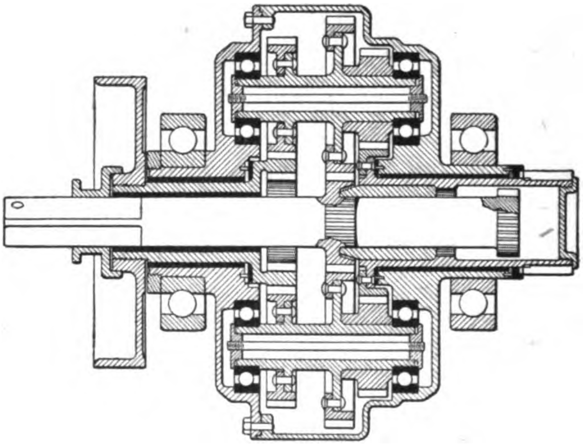


Fig. 144. Radcliffe Semi-Planetary Transmission.

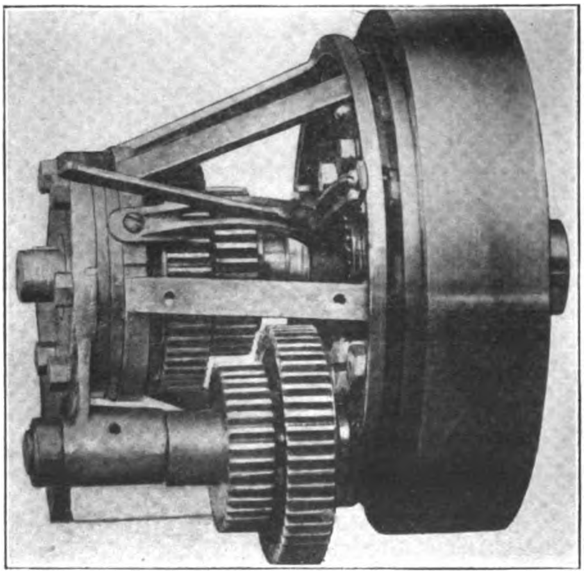


Fig. 145. Semi-Planetary Transmission.
Auto-Thrasher Company, Hutchinson, Kansas.

Friction Disk. Undoubtedly when simplicity is sought after, regardless of cost, the friction drive is the drive used. The cost with this form is not one of money, but rather of other things which must be sacrificed if friction drive is used.

Spur Type. In the interest of simplicity, it may be said that the friction form of drive dispenses with the clutch, being of itself both clutch and change speed gear. The usual form which this takes is the single spur wheel contacting with another flat-faced wheel. Since these must be at right angles, the car is nearly always a chain-driven one, the driving wheel being on the rear end of the crank shaft, and the driven shaft across the middle of the car. To secure a more certain drive and at the same time obtain the differential action, the cross shaft is often fitted with a pair of wheels, contacting with opposite sides of the driver, and mounted upon two independent shafts. As this method causes the two driven shafts to turn in opposite directions, a gear is necessary at one end of one of them.

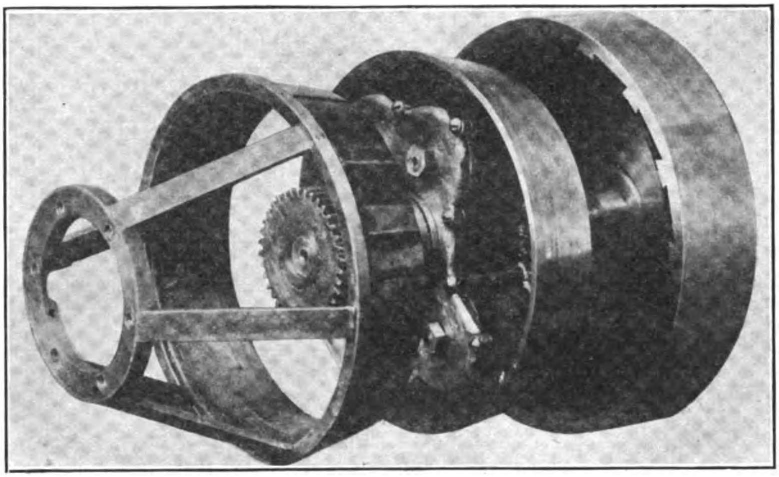


Fig. 146. Auto-Thrasher Transmission Showing Parts.

A very up-to-date application of the friction drive to a live rear axle, and showing incidentally the point just mentioned, is illustrated in Fig. 147. This is the rear axle of the S. P. M. A., a French car, in which a propeller shaft drives back to the rear axle upon which is mounted the friction transmission. In the latter there are three

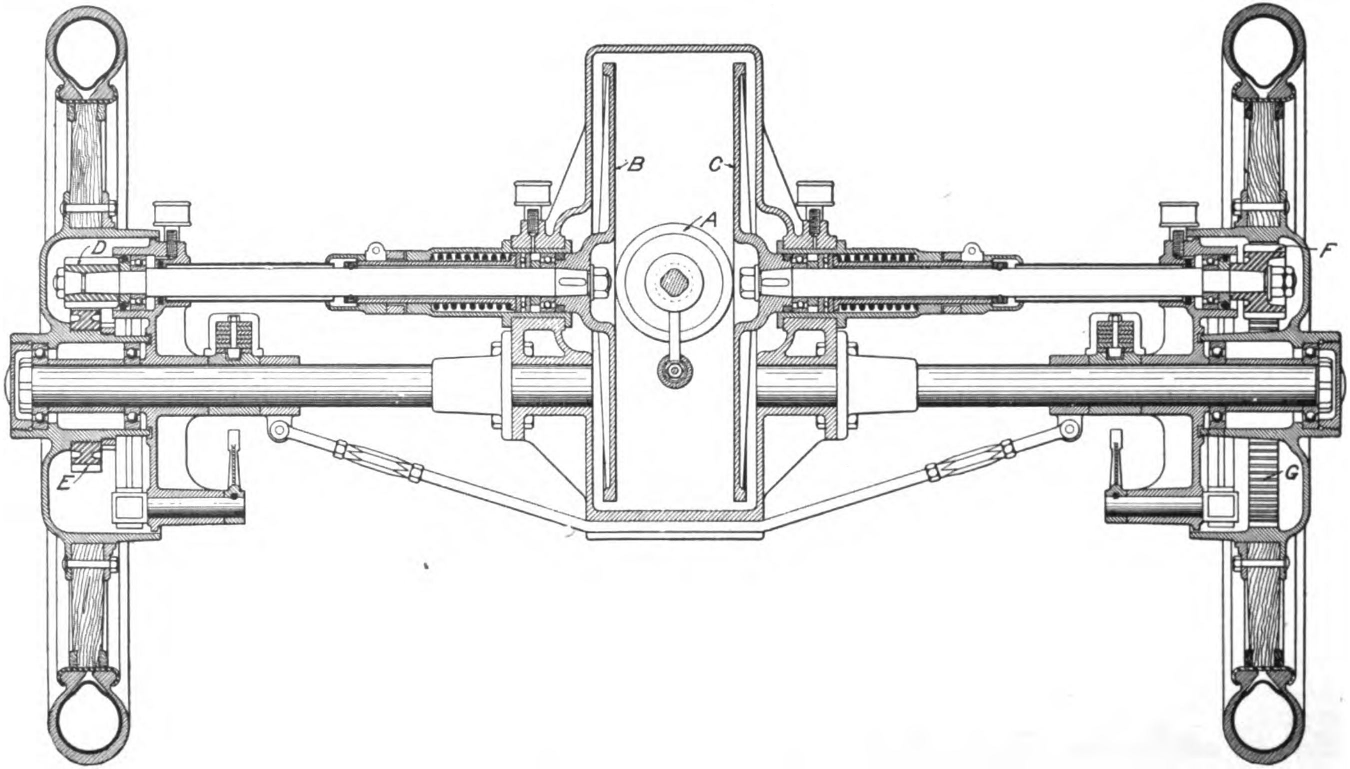


Fig. 147. Section of Rear Axle, S. P. M. A. (French).

wheels: a small driver *A*, and a large pair of driven wheels *B* and *C*. The latter, as was just explained, are driven in opposite directions but this is corrected at the outer ends where the final drive is located, the axle being of the full floating type. At these ends a gear drive is placed but the change of direction is obtained by the use of a spur gear *D* driving another spur *E* at one end and an internal gear *G* driven by a spur gear *F* at the other.

The greatest feature of the friction drive is the number of speeds obtainable, these being infinite in number, since every different position of the driven wheel on the driver results in a different ratio and, consequently, a different speed. To obtain these various changes, the wheel which meets the other edge on, is usually arranged to be advanced up to and withdrawn from the wheel presenting the flat surface. In action, a motion of translation is given to the wheel at the same time as the motion up to or away from the surface. This motion of translation changes its position and consequently its speed.

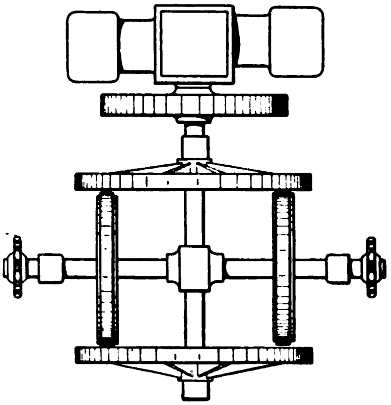


Fig. 148. Four-Disk Friction Transmission.

Over the three-wheel arrangement, the use of four possesses some undeniable advantages, particularly if the two parallel driving wheels are arranged to drive the others in pairs. This achieves the result that the direction of rotation of the wheels is alike, and no intermediate gear to change the direction of one shaft is needed. In Fig. 148 it may be seen that the two cross shafts do not line up exactly, the one at the right being set slightly in front of the left one. This keeps the right-hand friction out of engagement with the rear driver, and the left out of contact with the forward driving wheel. The two driven wheels must be shifted together, or otherwise, a different speed will be produced in the two rear wheels. A simplification of this utilizes the flywheel of the engine as the forward driving disk.

Bevel Type. Bevels have much to commend them as opposed to the spur friction wheel. They are found in combinations, such as a single pair of bevels, three, and in multiple combinations, without limit to the number. Fig. 149 shows the use of a single pair, but in combination with a flat face on one and a spur attached to the other, making the whole consist of four wheels in reality. This is the drive as used on the Metz cars, particularly their small commercial cars.

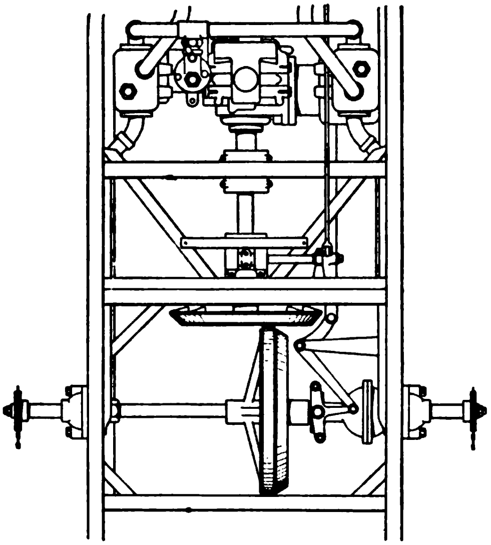


Fig. 149. Friction Transmission with Bevels.

In Fig. 150 is presented another combination—three bevels, one of them with a flat face and a spur, making really five wheels—in which are many novel features in that the spur wheel in every case takes the final drive, and also, in that a direct drive on the high gear is obtained by the use of a cone clutch on this spur, and another with which it engages on the driving wheel. One bevel gives forward speeds and through the other the various reverses are gained.

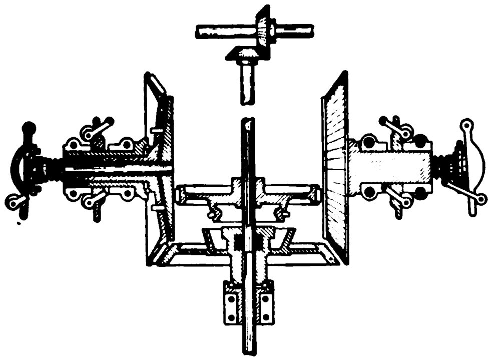


Fig. 150. Friction Transmission with Three Sets of Bevels.

Multiple bevels are used exclusively in the drive of the Meiselbach commercial cars, made in Milwaukee, Wis., Fig. 151. Seven bevels are necessary here—three separate drivers, and four different driven ones being provided. Bevel *E* gives the low speed forward, the two large wheels in every case being driven oppositely, which is corrected by the use of spur gears *L*. *D* gives the high speed, and *C*, closest to the engine, the reverse, which is of equal speed with the low.

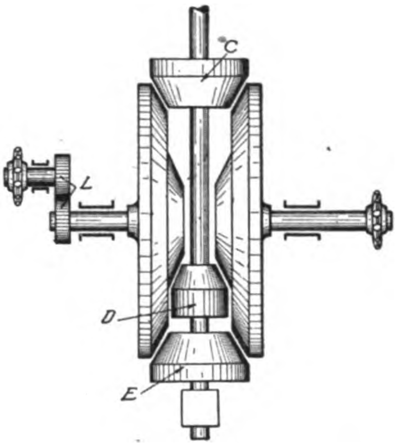


Fig. 151. **Transmission of the Meiselbach Commercial Car.**

A similar but more complicated device, the transmission used by the Parr Motor Truck Company, Pittsburg, Pa., upon their commercial cars, is shown in Fig. 152. In this two parallel shafts are used, these being geared from the crank-shaft extension by means of equal sized gears, shown at the left. Upon each of the two shafts is mounted three bevels, two of one size, and one smaller. These may be brought into contact with three similar surfaces on the driven disks, to which are attached the driving sprockets, the cars being double chain driven. By meshing the forward pair of frictions, the car is driven backwards; when the rear pair are utilized the result is slow speed forward; and the middle wheels give high speed forward. Except to eliminate the small spur gear, it is hard to see the advantages of this over the other, whereas its additional complications are self-evident. There may be other and different combinations of friction driving devices, but it is not the aim of this article to go into

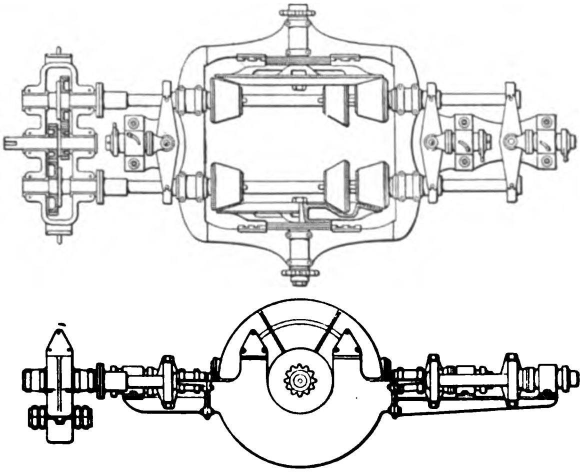


Fig. 152. **Multiple Bevel Arrangement.**
Parr Wagon Company, Pittsburg, Pa.

the details of every drive under the sun, but only the principal ones, and those in most common use.

Miscellaneous Types. *Freak Drives.* What are termed the freak drives attract much attention from inventors but little from hard-headed constructors. Thus, the belt drive was once advanced as *the* simple drive, yet it made no progress. Today there are practically no belts used for final driving in America, although a few are still made on the other side. There is a French car, Fouillaron, of low price, with this drive, and a single-cylinder Italian car, the Otav, selling for the equivalent of $150, is also so equipped.

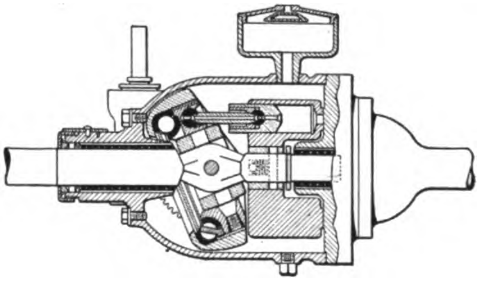


Fig. 153. Section Through Motor of the Janney-Williams Hydraulic Transmission.

Cable Driving. Cable driving has in the past attracted many in the motor buggy field, but today it is losing its popularity, and is fast being replaced by the chain.

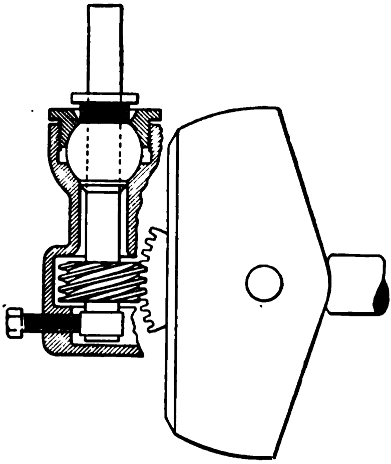


Fig. 154. Worm Gear in Janney-Williams Hydraulic Transmission.

Hydraulic Gear. Of late years the hydraulic transmission has been advanced as a cure for all automobile troubles, representing as it does the elimination of clutch, differential, and the driving mechanism. It consists of a pump to circulate the fluid, and one or two motors to be propelled by the same, usually attached to the rear wheels. In the Janney-Williams hydraulic gear, which has been successfully used for some time in other fields, but has just recently been tried for automobiles in England, there are three similar pumps, one being used as a pump and the other two as motors. Fig. 153 shows a section through this; Fig. 154, the worm drive for it; and Fig. 155, the general arrangement of the drive, the engine end being the same as in any other case. By rotating the driving ring, shown inclined in Fig. 153, so that it assumes different angular positions, the throw of the small pistons, of which there are nine in all, is varied from zero up to a maximum. Since the action of the fluid in the motors connected to the wheels is just the opposite of this, it is equivalent to varying the speed, the number of changes being infinite as in friction gearing. The worm drive, Fig. 154,

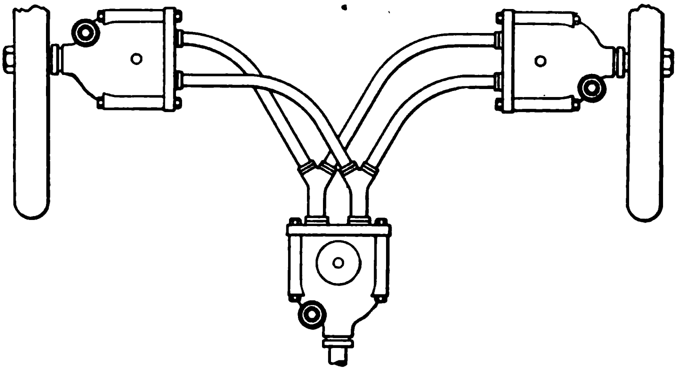


Fig. 155. General Scheme of Janney-Williams Hydraulic Gear.

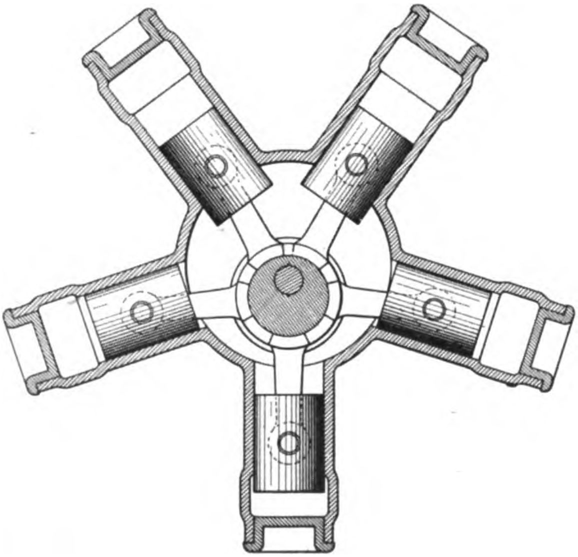


Fig. 156. Manly Fluid Transmission with Multiple-Cylinder Arrangement.

governs the speed changes, a rotation of the shaft moving the driving plate and changing the speed of the vehicle.

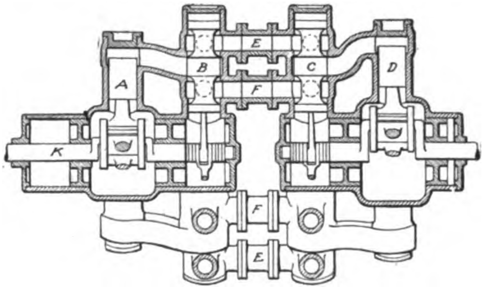


Fig. 157. Section of Manly Drive.

Another hydraulic drive of equal merit and of American manufacture, is the Manly, Fig. 156 and Fig. 157. As is shown, this differs from the Janney-Williams only in the form of the motors; the fluid and its use are the same in both cases. This drive has for its object, first, the securing of any desired speed of the driven shaft, either forward or backward, without changing the speed or direction of motion of the driving shaft; and second, of transmitting the power to a shaft which is either in line with the driving shaft or which lies at any angle to the driving shaft and separated therefrom. It consists of a multi-cylinder pump—*A* and *D* being two of the cylinders—with variable stroke which is attached to the driving shaft, and one or more multi-cylinder motors—two being shown at *B* and *C*—having a fixed stroke, which are attached to the driven shaft *K*, together with pipe connections or passages *E* and *F* between them for transmitting the working field. The various cylinders, both of the pump and motors, radiate equidistantly from a central crank chamber, and the pistons or plungers are connected to a single crank pin, which is common to all. The fluid used is ordinary machine oil, the lubricating qualities of which, and its freedom from the danger of freezing, admirably fit it for such a purpose. When the system is once filled the oil is used over and over again, being in continuous circulation from pump to motor through one set of pipes or passages and back again from motor to pump through another set. The stroke of the pump may be varied at will; that of the motor is fixed. The variation of the pump stroke is accomplished by a crank on which is mounted an eccentric bushing. By revolving the bushing with reference to the crank its center line is brought into alignment with the center of the shaft, and when this position is reached no reciprocating motion is communicated to the pump plungers. The

Manly drive is made in New York City, and has been successfully tried there on a delivery wagon, this being selected as likely to give the most severe test possible.

Pneumatic Drive. There has been some talk of a pneumatic drive also, this idea not being so very far from the previous one of using liquids. In this scheme a very large tank of compressed air is provided for the purpose of starting the engine, helping to get up speed quickly, and on hills when excess power is needful or at least helpful. If used as planned it would allow of the elimination of the reverse and would be utilized for braking as well, the present form of band brakes being replaced by air brakes. This is but a prospective scheme, never having been tried; yet in considering the future, it is worth more than a passing thought because of its latent possibilities.

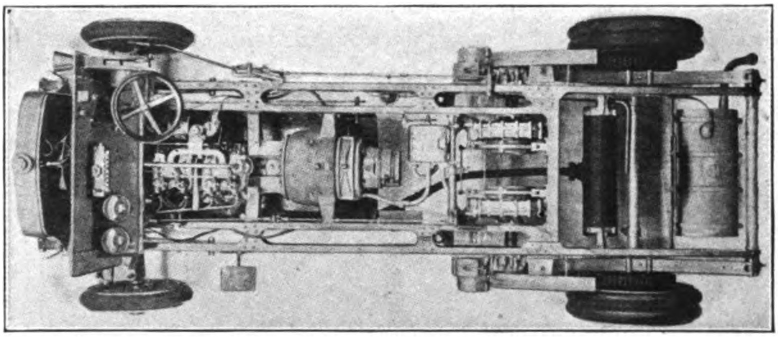


Fig. 158. British Thomson-Houston Company's Gasoline Electric Chassis. View From Above.

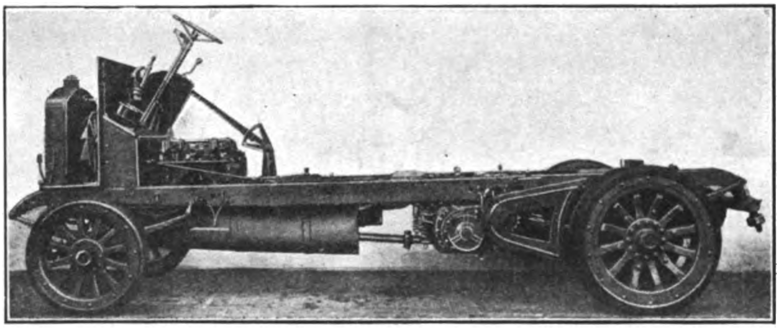


Fig. 159. British Thomson-Houston Gasoline Electric Chassis. Side View.

Electric Drive. To speak of an electric drive sounds peculiar, yet that is what should be used for a final drive through the medium of electric motors. This form, spoken of abroad as the *petrol-electric car*, is attaining much headway there. It gains slowly, it is true, but, nevertheless, surely—each year seeing one or more added to the already long list of successful cars in this category. To mention a few of these — Mercedes and Krieger are recognized as leading German makers, while Gem, Vate, and Auto-Mixte are of high rank in France, and Peiper, Hallford, Electromobile, Hart-Durnall, Thomson-Houston, and Silvertown, as well as others of equal rank in England, not to forget Columbia, Couple-Gear, and others in this country. All these have done good work in furthering the cause of the electric drive. In Fig. 158 and Fig. 159 are shown a plan and side view of the most excellent gasoline electric chassis built by the British Thomson-Houston Company. These are in service in London as motorbuses, in which service they have shown up to very good advantage. Fig. 160 shows a drawing of the construction of the wheels of the Mercedes gasoline electric vehicle, in which the motors are carried within the wheels themselves. In this, the front wheels only are active. As shown in

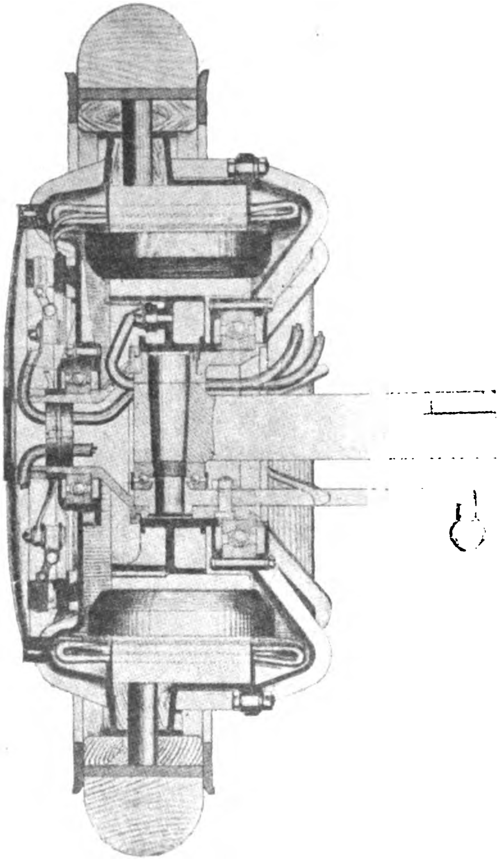
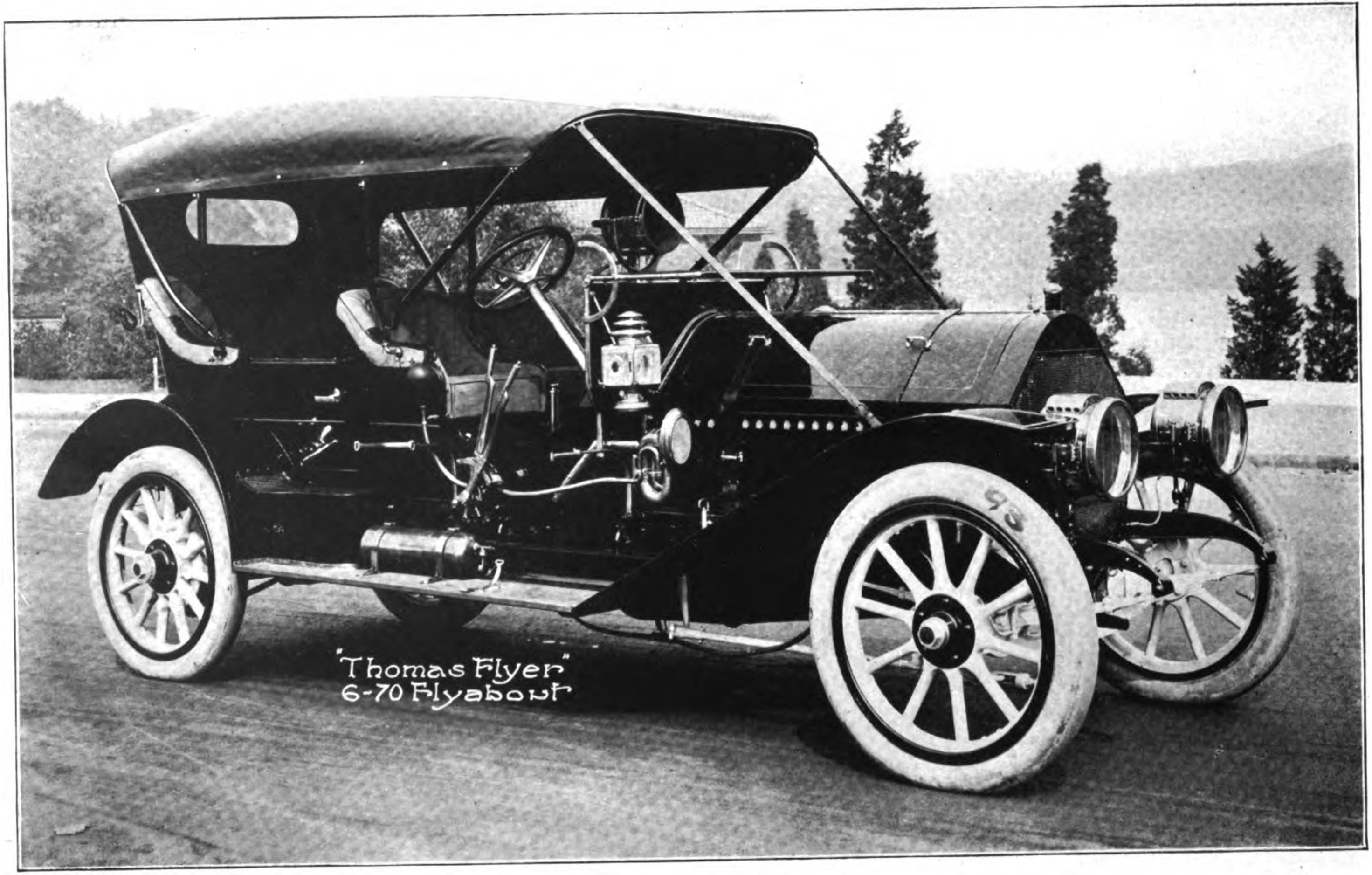


Fig. 160. Section Showing Principle of Action of Mercedes Gasoline Electric Drive.



SIX-CYLINDER 70-HORSE-POWER FLYABOUT
E. R. Thomas Motor Company, Buffalo, N. Y.

Fig. 161, they are readily dissembled in case of trouble on the road, not even a jack being necessary. This view also shows all of the parts composing the motor within the wheel.

Differing from this very markedly is the other prominent German advocate of mixed driving, as the gasoline-electric system is sometimes called. This is Kreiger, whose chassis is shown in both plan and elevation by Fig. 162. In this, it will be seen that the generator is coupled to the back of the engine in the place ordinarily occupied by the flywheel and clutch, the rotating armature, in fact, acting as a flywheel. Then the motors are set one on each side, directly in front of the rear wheels, which they drive through the medium of spur gears, the whole being enclosed to keep out dirt, keep in oil, and reduce noise to a minimum.

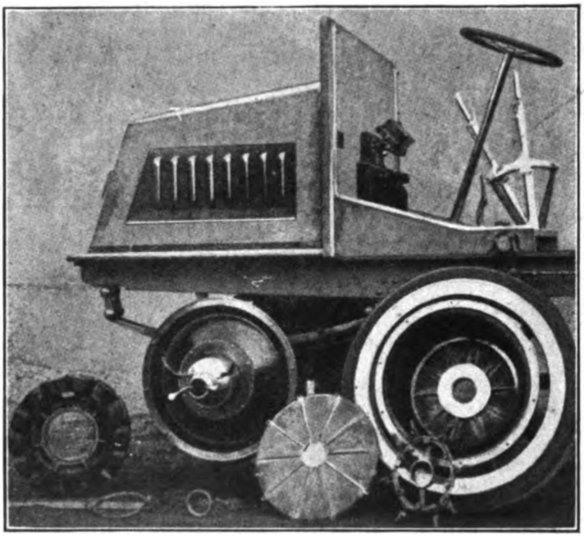


Fig. 161. Mercedes Driving Wheel Dissembled.

On the whole, the electric drive is losing no ground, which, in these days of gasoline shaft-driven cars, is perhaps something gained. In fact, it might be said that it possesses so many advantages which are worth having even at a sacrifice, and so few disadvantages that one is safe in figuring that a few more years will see the number of these doubled and possibly trebled.

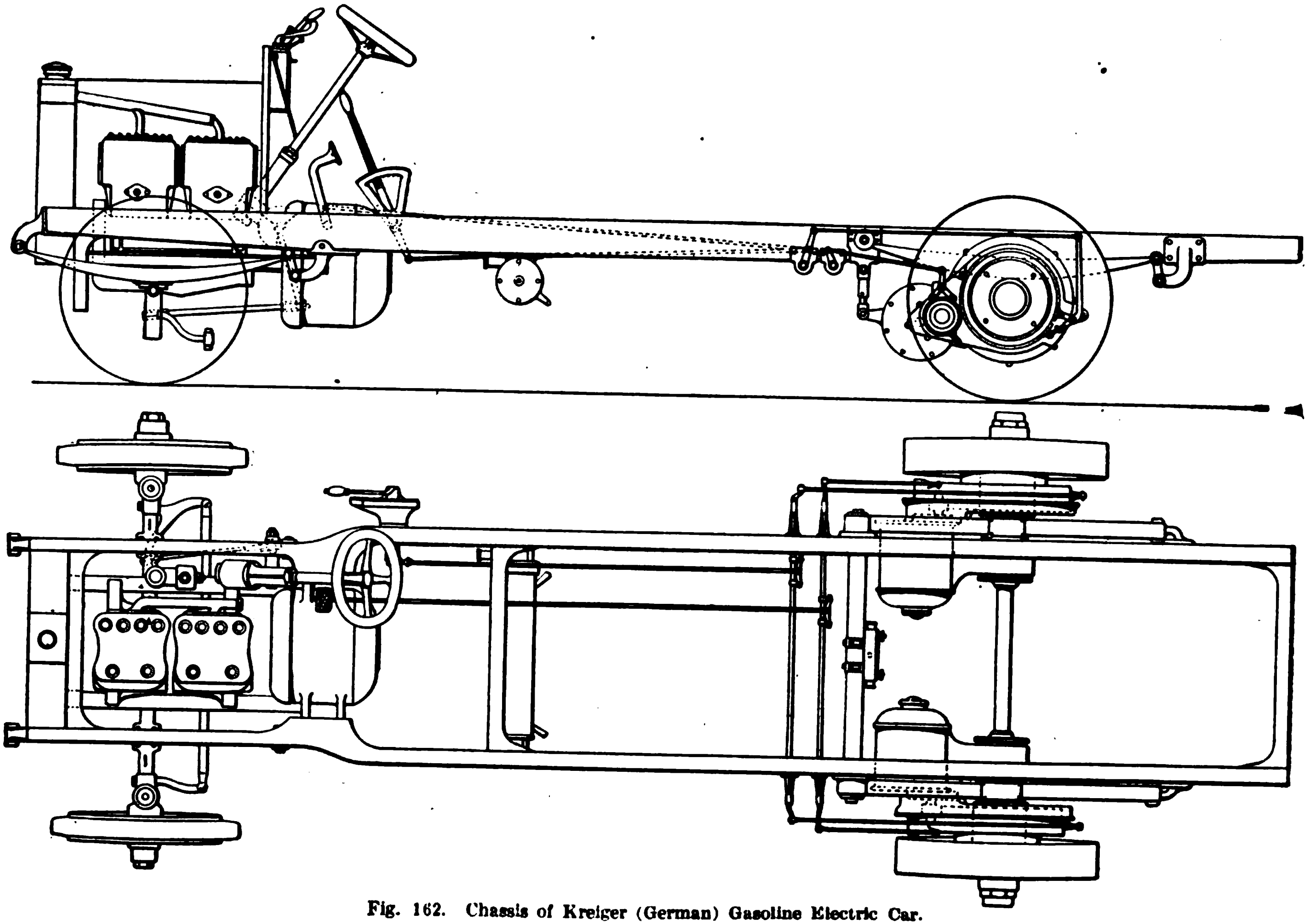


Fig. 162. Chassis of Kreiger (German) Gasoline Electric Car.

GEARS

Since the whole subject of transmission concerns itself with gears, it will not be out of place to discuss the gears themselves and describe the many different kinds in use. Speaking broadly, the gears used may be classified according to the position of their axes, relative to one another. Thus we have axes parallel and in the same plane; parallel but not in the same plane; at right angles and in the same plane; at right angles and not in the same plane; at some other angle than a straight or a right angle and in the same plane; and the same, but not in one plane. These classes give us the forms of gear in common use; viz, spur gears, bevel gears, helical gears, herringbone gears, spiral gears, and worm gears.

Spur Gears. A spur gear being by far the most common kind of gear, is the easiest to describe, consisting as it does of a round flat disk with teeth cut in the exterior circumference, *i.e.*, around the periphery of the disk. The cutting of these teeth has had much to do with their universal use, since the very low cost of cutting the teeth due to special machinery developed for that purpose, just about explains the matter. Formerly, the teeth were cut, one gear at a time, in the milling machine, this being practically a hand operation, since all movements of the gear or cutter had to be made by hand. Later, improvements made it possible to cut more than one gear at a time, which resulted in lowering the cost per piece slightly but did not eliminate the objectionable feature—the hand work.

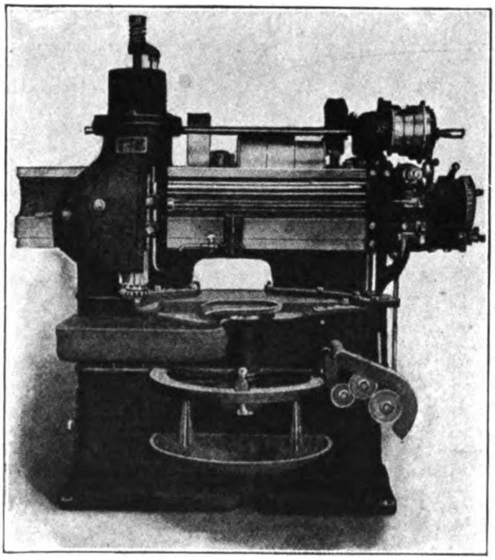


Fig. 163. Fellows Shaper for Cutting Gear Teeth.

Step by step special machinery was developed for this work, until finally a perfected machine was brought out which does all of the work. With this machine, the workman places the cutter on the machine spindle, sets the gear blanks into position, and starts the machine, after which it goes on automatically cutting tooth after tooth to a correct shape, until the gear is finished, when the workman is again necessary to shut it off, and, after taking out the finished gears, put in a fresh supply of gear blanks.

This machine, known as the *Fellows gear shaper*, Fig. 163, has reduced the manual labor of gear cutting to such a point that it is possible for one man to operate, unassisted, from three to six machines at one time. Usually these are placed together and located near the automatic machinery, a group of them being called a *battery*. By having a battery of five machines cared for by a single man, the cost of spur-gear cutting has been brought down to the absolute limit.

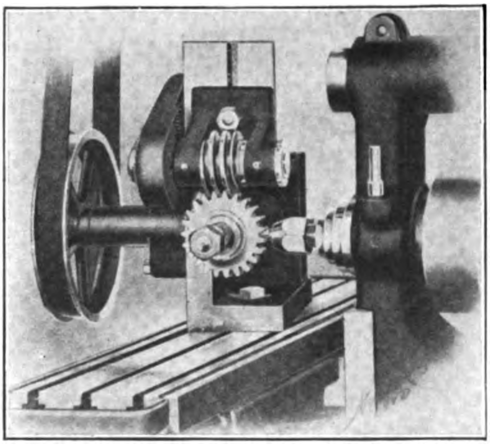


Fig. 164. Tooth Chamfering Attachment.

Bevel Gears. Bevel gears, in which the shafts are at right angles and in the same plane, or in the same plane but not at right angles, are more difficult to cut and therefore less used. Their cutting is now done, like the spurs, in an automatic, or nearly automatic, machine, which requires little attention, but it does require more care than the spur-gear machine. Its greater complication makes it not only more difficult to understand and operate, but, of course, increases its initial cost and the cost of operation. All of these things militate against the bevel, so that many shops have the slogan, "Never use a bevel gear unless it is absolutely necessary."

Both spurs and bevels sometimes require a chamfered tooth edge, spur gears as used in the Panhard or clash gear transmission always being in need of it. This work was formerly done by hand, using a hammer and chisel, but now a special machine has been manufactured for this purpose by the Long Arm System Company, Cleveland, Ohio. This is known from the work it does as an *automatic tooth chamfering attachment.* Fig. 164 shows the general appearance of it and Fig. 165, the construction.

There are no real restrictions against the use of the spur and bevel, either or both being used interchangeably. Very often they are used in combinations which appear peculiar, as the one shown in Fig. 166. This is the final drive and reduction gear of the Autocar commercial cars, made by the Autocar Company, Ardmore, Pa. In this it will be noticed the drive from the engine is to an intermediate shaft through bevels. Thence, the final drive is by spur gears, from the intermediate shaft to the rear axle.

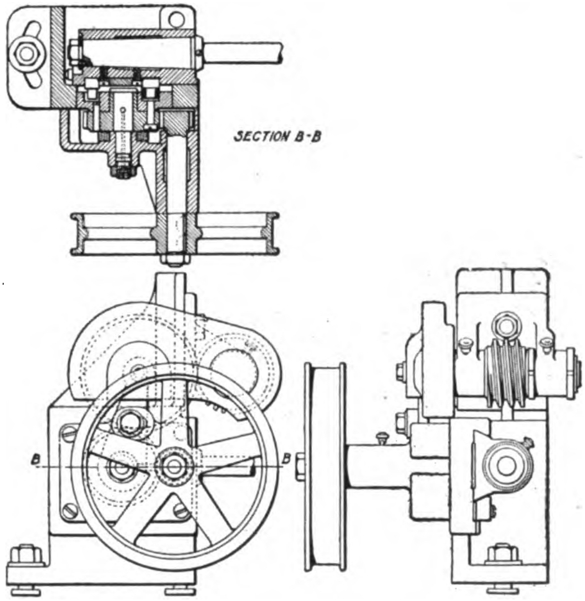


Fig. 165. Sections Through the Long-Arm, Tooth-Chamfering Machine.

Helical and Herringbone Gears. In situations where quiet running is deemed necessary, the use of a *helical* gear frequently finds favor, since it accomplishes the desired result, although the cost of cutting is high. Of late, these have come into general use for camshaft drives and similar places. A pair of helical gears set so that the helices run in opposite directions, forms a *herringbone* gear. This is even more quiet in its action than the single helix, and possesses other virtues as well. One well-known firm has adopted it for camshaft driving gear, and makes it as described to save cutting cost, as the cost of cutting a true herringbone would be prohibitive. So, a pair of helical gears of opposite direction are set back to back and riveted or otherwise fastened together, forming a herringbone gear at a low cost. Both of these may be used when the two shafts are parallel and in the same plane, but for cases where the shafts are neither in the same plane nor parallel, some form of spiral gear must be used.

Spiral Gears. Spiral gears as such not being generally understood, and that variety of the spiral gear known as the *worm* being very simple and easily understood, the latter has attained much popularity within the past three years. This has been due in part to superior facilities for cutting correct worms and gears, but, in the main, to a superior knowledge of the principles upon which the worm works, and the things which spelled failure or success. Thus, one of the earliest experimenters in this line laid down the law that the rubbing velocity should not exceed 300 feet per minute if success was desired, or in rotary speed about 80 to 100 revolutions. For automobile use, this was out of the question; but later experimenters found that these re-

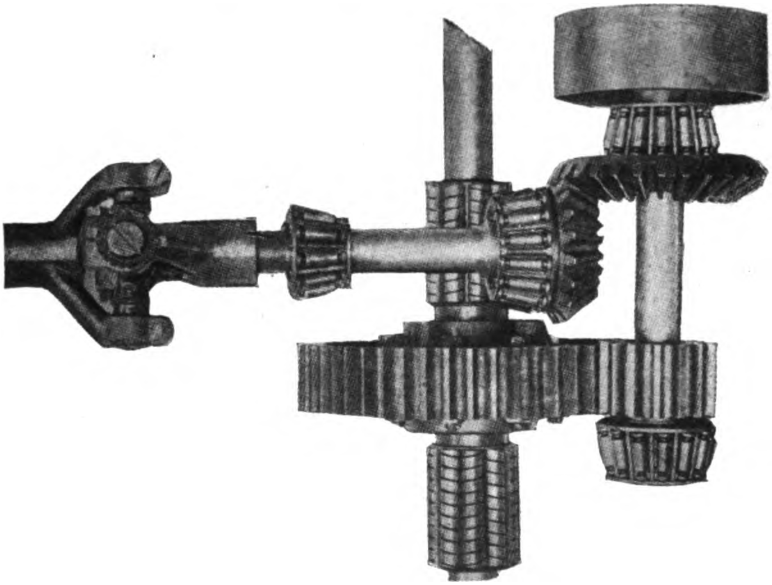


Fig. 166. Combination of Gears in the Autocar Final Drive.

sults only attached to the forms of gear used by the early workers, and did not apply to a strictly modern gear laid down on scientific principles.

The mistake made was in the pitch angle of the worm, which was formerly made small, nothing over 15 degrees being attempted. This was the item which was at fault and caused this very useful and efficient mode of driving to fall into disuse. As soon as this fact was ascertained and larger pitch angles utilized, better results

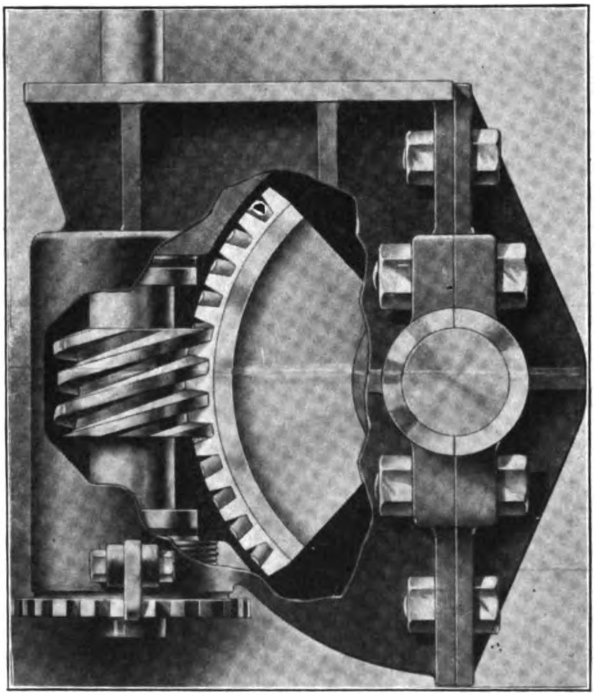


Fig. 167. Hindley Worm Steering Gear for Heavy Trucks.

were attained until with 20 degree angles, 700 feet per minute pitch line velocity was attained, followed shortly by the use of even higher angles, resulting even more successfully. As the efficiency depends directly upon the pitch angle, these changes brought the efficiency of this form of gearing from the former despised 30, 40, and sometimes 50 per cent up to 87, 88, and even 90 per cent, thus putting it on a par with any but the very best of spur gears, and above bevel gearing. In fact, in the light of modern knowledge of worm gears, it would be possible to say without departing from the truth that it is possible to obtain from this form an efficiency of 93 per cent. In automobile work it has been used mostly for steering gears and final drives. For the former its irreversible quality is brought out, while for the latter this must be made subordinate to a very great reduction which may be attained in a very small, compact space. Many modern machines make use of it; as, Maxim-Goodrich electric, Franklin delivery wagon, Mitchell truck, Hamilton motor buggy, Dennis (English) busses and trucks, Greenwood and Batley (English) commercial cars, and numerous others. Figs. 167, 168, 169, and 170 show some common uses to which the worm is put, the first two being steering gears, while the last two are final drives.

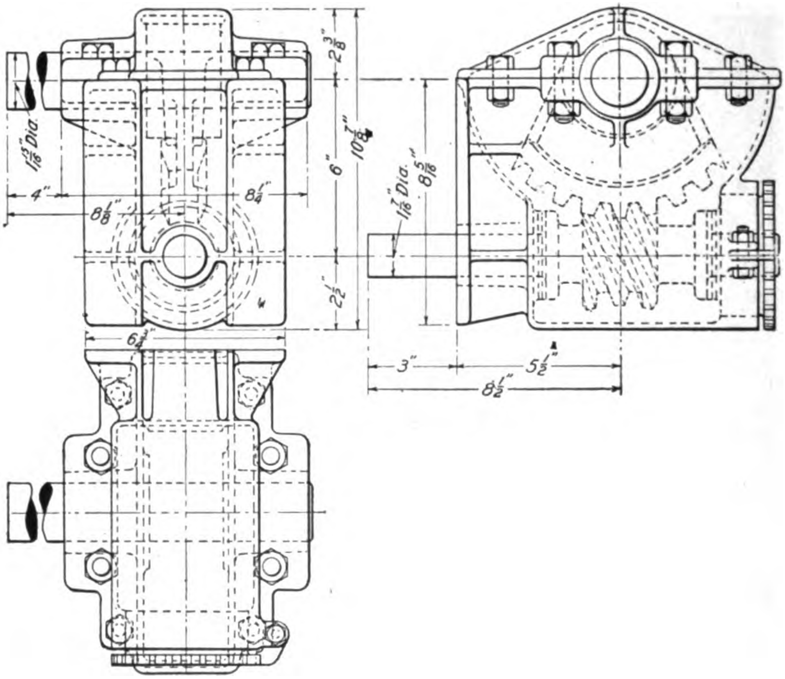


Fig. 168. Details of Hindley Worm Steering Gear.
Morse-Williams Company, Philadelphia, Pa.

BRAKES

Next to having the proper power, applied through the correct form of gearing to conserve it, and its final suitable drive to the road wheels, nothing is of more importance than the ability to stop the vehicle at will. The first step is to have a machine that will function correctly, that is run at will, and following that it is necessary to be able to bring it to a stop, both to avoid danger and otherwise. The medium through which this is done and which ordinarily suffices, is the shutting off of the source of power—in this case, the gasoline and the spark which is used to ignite its vapor. This will not always suffice, however, for the ordinary car possesses the ability to run at a speed of 40 miles per hour or upwards, and weighs from 2,000 pounds (one ton) upwards to 4,000 pounds (two tons). This combination makes for a large force of inertia, which will result in the car running for many yards, even hundreds of yards after the power is shut off. So it is that we must have a mechanical means of absorbing this inertia, or of snubbing the forward movement of the car. This is the function of the brakes, as fitted to the modern car.

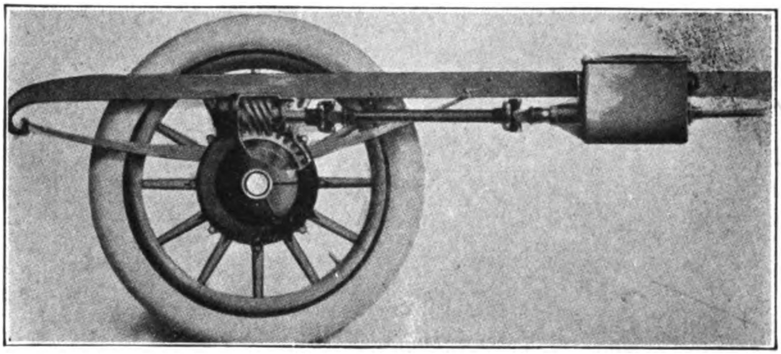


Fig. 169. Worm Gear Applied to Rear Axle Drive of Touring Car.

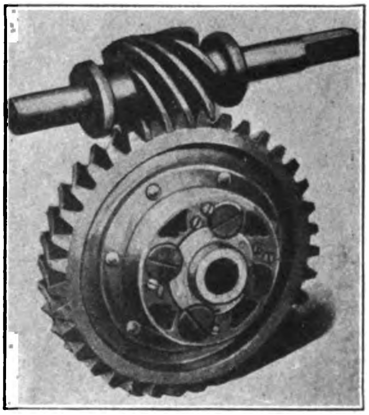


Fig. 170. Final Drive on Light Truck of Mitchell Motor Car Company.

Although disregarded in any summary of brakes, the engine is the best brake that a car can possess, granting that the driver knows how to use it so as to get the best results without doing any damage. The ordinary engine has a compression of from 60 pounds to 70 pounds per square inch, which is practically the pressure available when it is used as a brake.

Since this is far and away more than any other type or form of brake will yield, its usefulness is self-evident.

Aside from this, brakes are usually divided into two classes; differing mainly in location: the *internal expanding* and the *external contracting*. To this a third class should be added because it partakes of the nature of both yet differs from each one. This is the railway type of brake with removable shoes of metal, differing from the band type in that no attempt is made to cover the whole or even the greater part of the circular surface, but simply a small portion of it, against which a shoe is forced with a very high pressure. Both of the other types are subject to division into other classes, the first into three subdivisions according to operating means: cam, toggle, and scissors action.

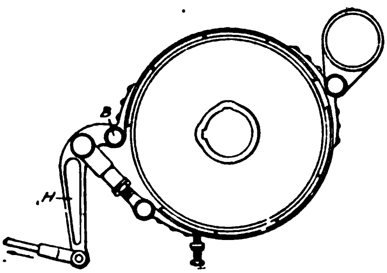


Fig. 171. Brake on Main Shaft of Benz (German) Car.

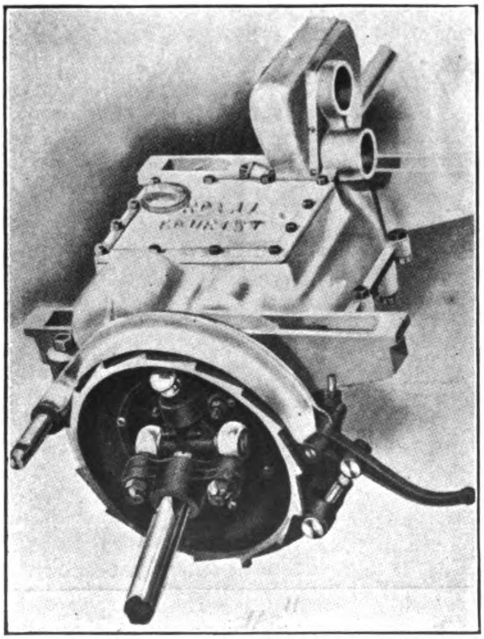


Fig. 172. Main Shaft Brake of Royal Car.

External Contracting Brakes. This class of brakes is subject to but two divisions: single and double acting. In the first, an end of a simple band is anchored at some external point, while the other or free end is pulled. This results in the anchorage sustaining as much pull as is given to the operating end, that is, all pull is transmitted directly to the anchorage. This disadvantage has resulted in this form becoming nearly obsolete.

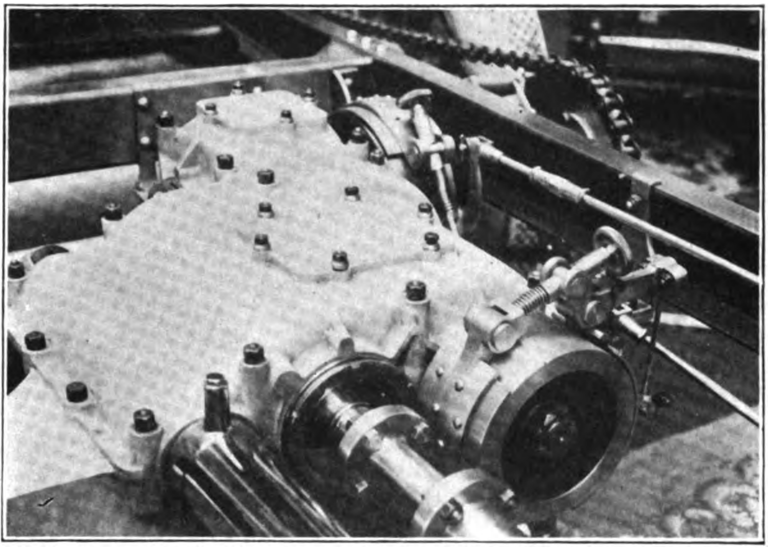


Fig. 173. Brake System on Bianchi (Italian) Car. Note Accessible Adjustment.

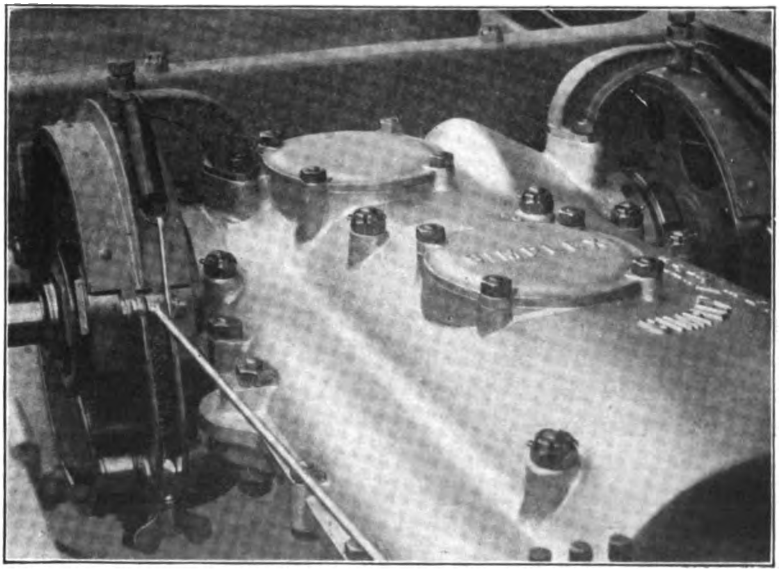


Fig. 174. A Pair of Brakes on Countershaft.
Simplex Automobile Company, New York City.

Any brake of the true double acting type will work equally well acting forward or backward. Fig. 171, the Benz differential brake, shows this clearly. The external band is hung from the main frame by means of a stout link, which is free to turn. Now, the band itself is of very thin sheet steel, lined with some form of non-burnable belting. The ends carry drop forgings, to which are attached the operating levers. These are so shaped that the pull is evenly divided between the two sides of the band. This will be made apparent by considering that a pull on the lever *H* will result in two motions, neither one complete, since each depends upon the other. First, there will be a motion of the upper band end *B* about the extremity of the lower one as a pivot, followed by a movement of the lower end, pivot and all, about *B* as a second pivot point. These two motions result in a double clamping action.

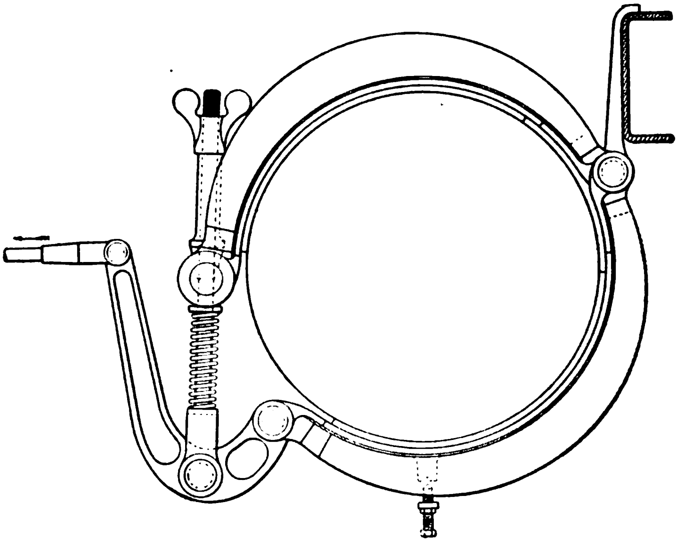


Fig. 175. Benz Countershaft Brakes for Chain-Driven Cars.

The Royal Tourist brake for the main shaft, Fig. 172, differs very little from this either in appearance or action. On chain-driven cars the brakes are given a different location to those on a shaft-driven car. Usually on the former there is provided three sets of brakes: one on the main shaft, one pair on the countershaft, and another pair on the rear wheels. In Fig. 173, showing the after portion of the

Bianchi car, an Italian product, part of two of these sets may be seen. On this car, the shaft brake is given an unusual adjustment, other things being subordinated to this. An excellent example of good designing is to be seen in the countershaft brakes, Fig. 174, of the Simplex cars, made in New York City by the Simplex Automobile Company. Despite appearances to the contrary, the principle upon which these brakes act is the same as the others just shown. The Benz fork brake, Fig. 175, which is noted for its consistent action, is an admirable brake. It is used on the countershaft, of the chain-driven cars and works as did the other Benz brake, the difference being in the details.

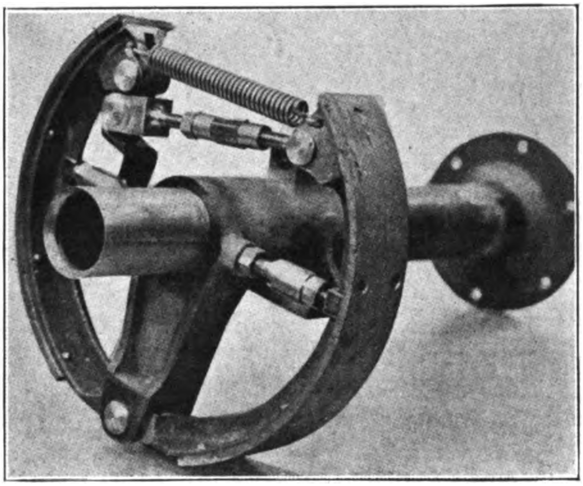


Fig. 176. Internal Expanding Brake of the Hotchkiss (French) Car.

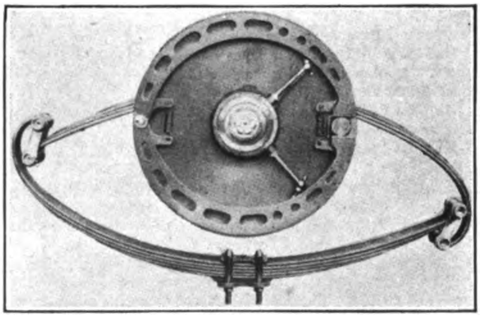


Fig. 177. Internal Expanding Brake of La Buire (French) Car.

Internal Expanding Brakes. While the contracting-band brake is well thought of, the internal-expanding form is rapidly displacing it for the reason that experienced drivers think more of it. In Fig.

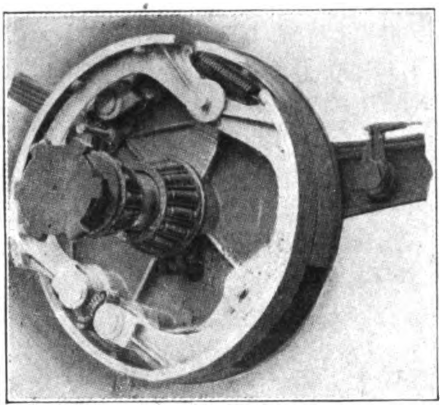


Fig. 178. Royal Rear Axle Brake.

176 is shown a foreign idea of an expanding band, this being a brake from the French Hotchkiss, built by the famous gun makers. This particular brake is from the four-cylinder, 16-horse-power car and possesses a pair of very wide shoes which are expanded by means of a lever and toggle arrangement. An excellent view of a cam-operated brake is shown in Fig. 177; this being from the other side as well. La Buire, a French car, uses this form on the rear axle, the view showing also the rear springs. An equally good American type is shown in Fig. 178, this being the rear axle brake from the Royal Tourist car of 50 horse-power. This will be seen upon close inspection to consist of two brakes set side by side on the same hanging and operating in the same brake drum.

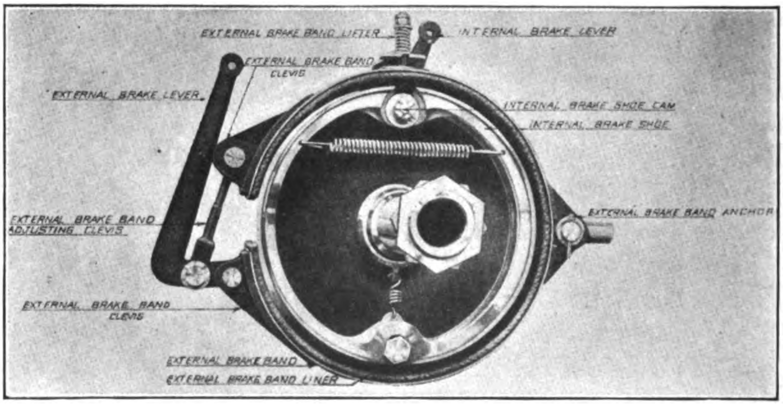

EXTERNAL BRAKE BAND LIFTER
INTERNAL BRAKE LEVER
EXTERNAL BRAKE BAND CLEVIS
EXTERNAL BRAKE LEVER
INTERNAL BRAKE SHOE CAM
INTERNAL BRAKE SHOE
EXTERNAL BRAKE BAND ANCHOR
EXTERNAL BRAKE BAND ADJUSTING CLEVIS
EXTERNAL BRAKE BAND CLEVIS
EXTERNAL BRAKE BAND
EXTERNAL BRAKE BAND LINER

Fig. 179. Peerless Rear Axle Brake.

More modern practice shows no tendency to place all of the eggs in one basket, both forms of brake being employed together and upon the same car, usually also upon the same brake drum, one set working upon the exterior while the other works upon the inside.

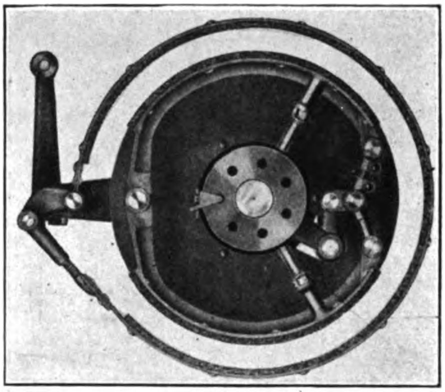


Fig. 180. Timken Double Rear Axle Brake.

In Fig. 179, which shows the rear axle brakes of the Peerless cars, made by the Peerless Motor Car Company, Cleveland, Ohio, this is plain to be seen, both of the brakes being shown although the drum upon which they work has been removed. The parts are all named so as to be self-explanatory. In this, as is usual, the inner or expanding band is operated by a cam. In the brake sets put out by the Timken Roller Bearing Axle Company, Canton, Ohio, in connection with their bearings and axles, the toggle action is used, Fig. 180. The constructional drawing, Fig. 181 and Fig. 182, showing the

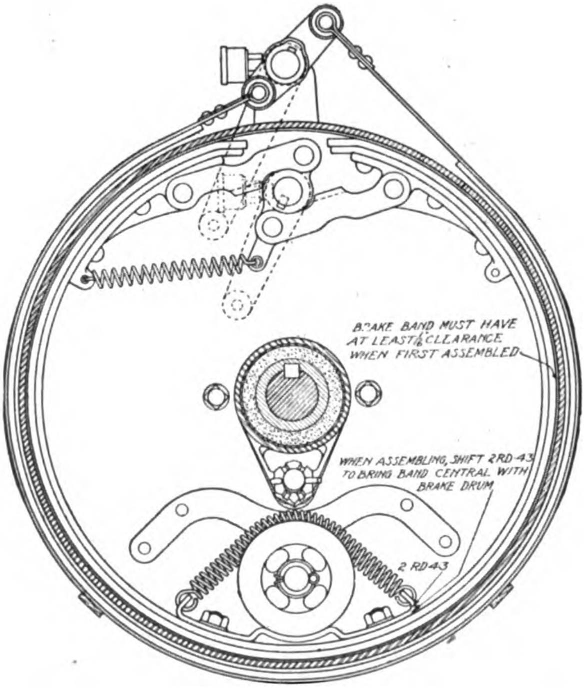

BRAKE BAND MUST HAVE AT LEAST 1/16 CLEARANCE WHEN FIRST ASSEMBLED
WHEN ASSEMBLING, SHIFT 2RD-43 TO BRING BAND CENTRAL WITH BRAKE DRUM
2 RD43

Fig. 181. End View of the Double Brake of Reo Car.

brakes used on the Reo car, manufactured by the Reo Motor Car Company, Lansing, Mich., indicates that this firm is partial to the cam for brake operation, since these are used for both internal and external brakes. The usual method, however, is more like that shown in Fig. 183 or Fig. 184, the internal brakes being operated by cam, while the double-acting, contracting bands work through levers.

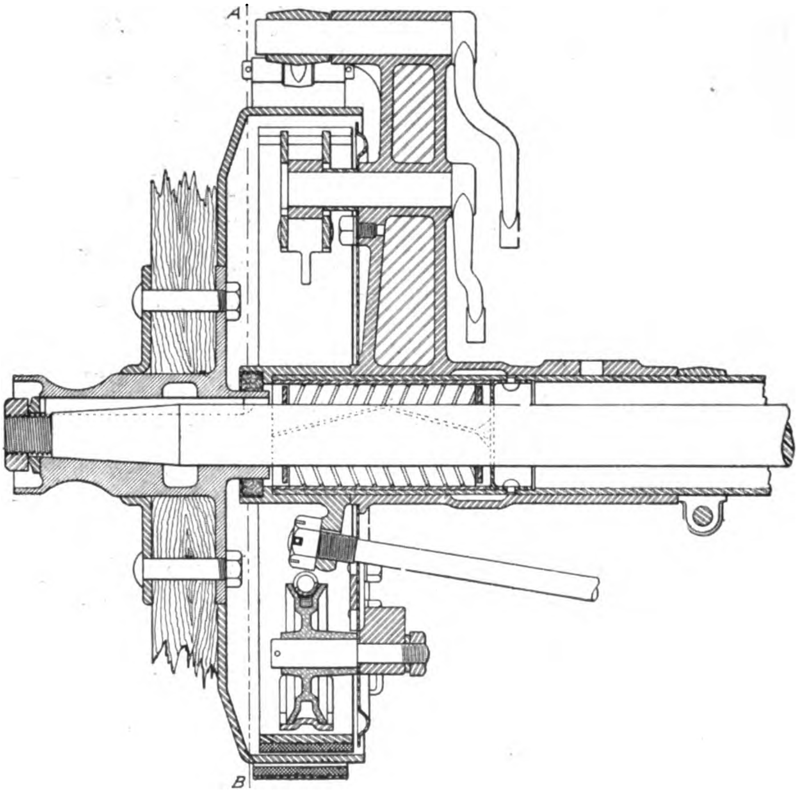
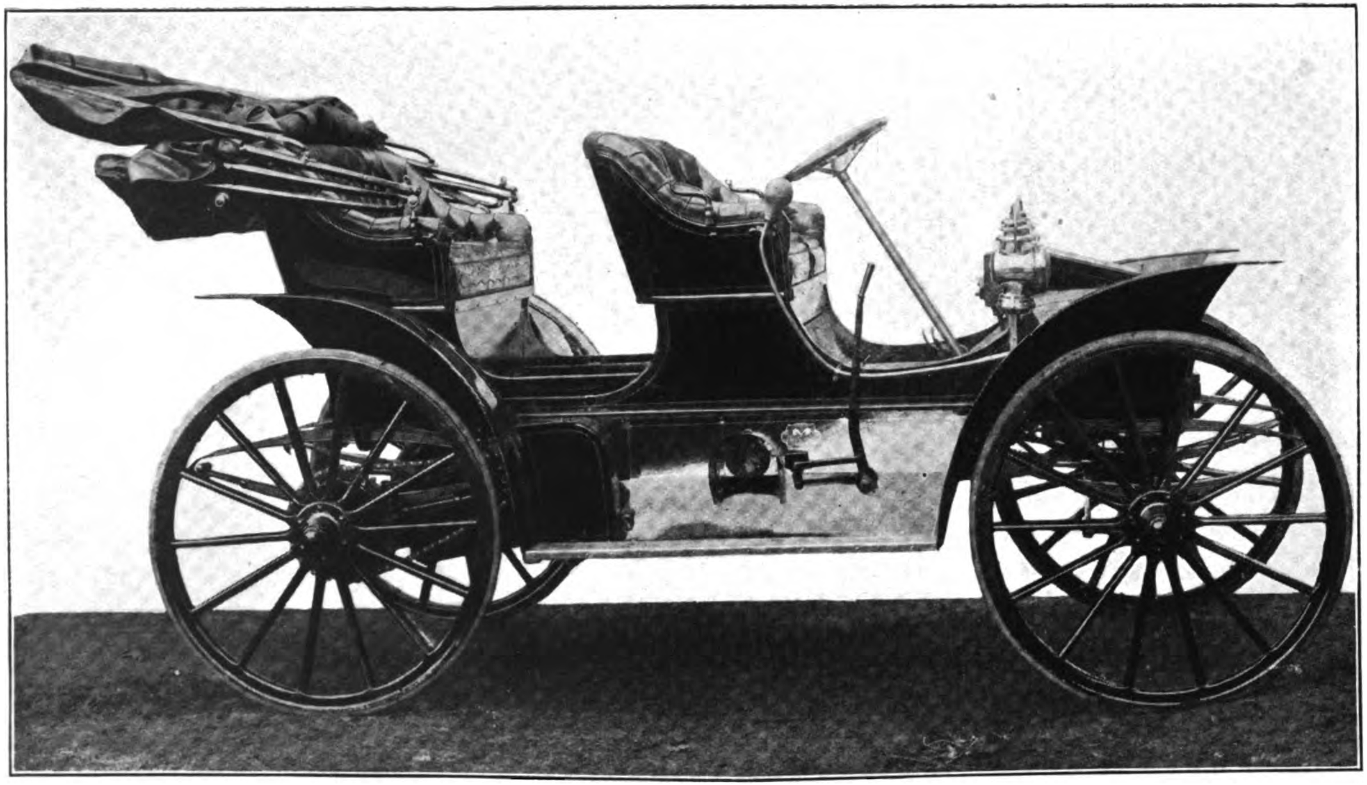


Fig. 182. Section Through Reo Brakes.

Principle of Brake Operation. The principle of brake operation is perhaps made most clear by a little excursion into the design of a set of brakes. The master formula for this is

$$K = \frac{Wv^2}{2g}$$

in which K represents the energy of the moving mass, W its weight, v its velocity, and g the acceleration due to gravity or 32.2 feet per



THE AUTOBUG, MODEL FIVE-TWENTY-FOUR
The "Autobug" Co., Norwalk, Ohio.

second. By applying to this the weight of a vehicle, such as 2,240 pounds, and reducing the whole to miles per hour, the formula may be put in the form

$$K = WV^2 \times .0334$$

from which 20 miles per hour gives 29,920 foot pounds of energy.

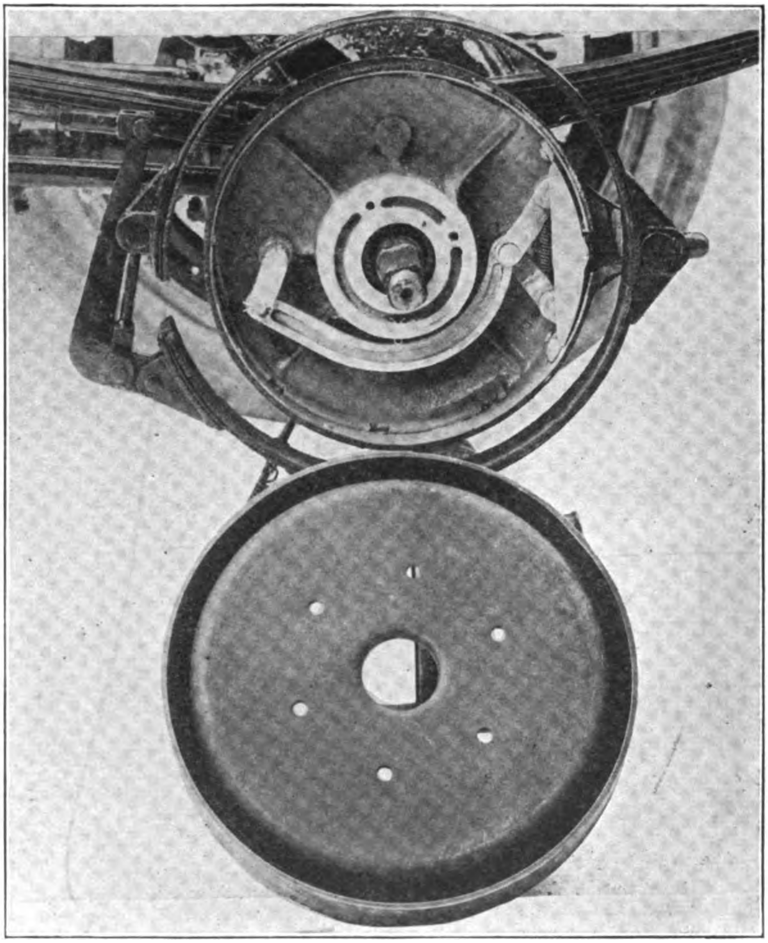


Fig. 183. Knox Internal Brake Showing Toggle Expansion.

Since distance in which the brakes will act is of value, it may be found by introducing into this formula two factors, the proportion of the total weight which the braking wheels will bear, and the coefficient of friction between the road surface and the rubber tires. The former may be taken as $\frac{6}{10}$ of the whole and the latter as .60. Including these in the expression; it takes the form

$$l = \frac{WV^2 \times .0334}{kw}$$

in which l is the distance in which a braking effort sufficient to slide the wheels would stop the car; k is the coefficient of friction; and w is $\frac{6}{10}$ of the weight of the car. This gives 37.1 feet for the value of l for the vehicle figured above and moving at the same speed.

In proportioning the parts, it will be necessary to know the pull on the band, which is equal to

$$P = kw = \frac{WV^2 \times .0334}{l}$$

and this for the car and speed as before works out to 806 pounds. Using a material in which the strength was 60,000 pounds per square inch and a factor of safety of 6, the sectional area at the weakest point should be

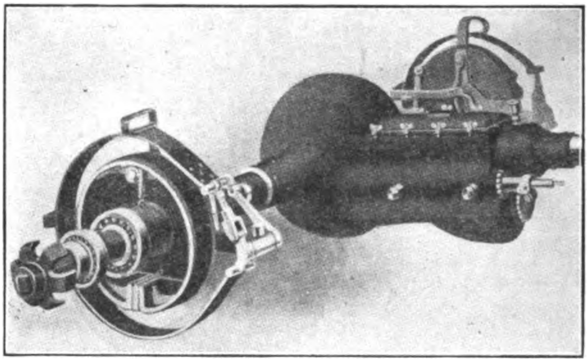


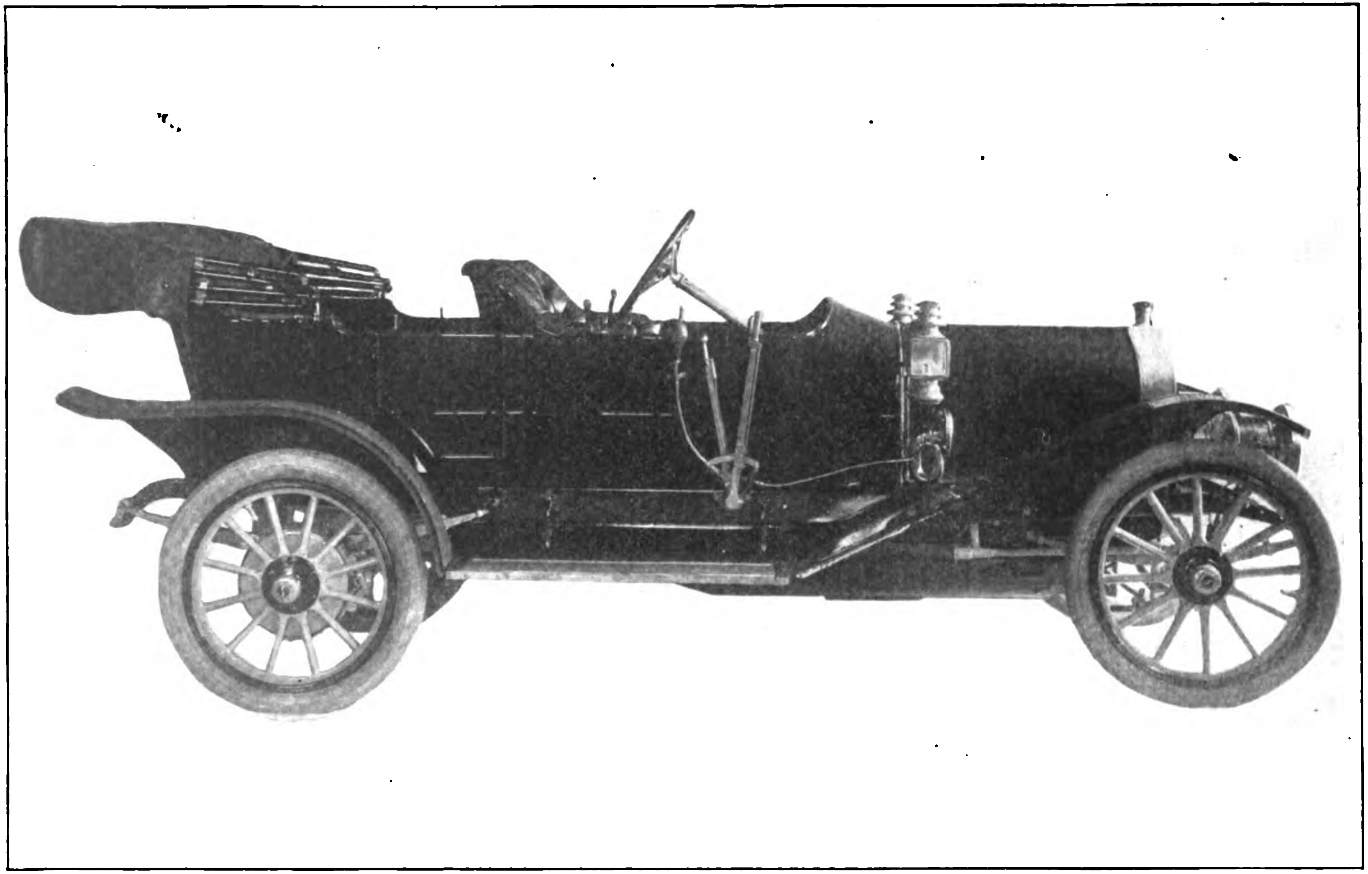
Fig. 184. Rear Axle and Brake Construction.
Pennsylvania Motor Car Company.

$$\text{Area} = \frac{806 \times 6}{60{,}000} = .0806 \text{ square inch}$$

If round iron were to be used, $\frac{3}{8}$ inch diameter would be safe while in a flat section such as the band itself, $\frac{1}{16}$ inch by $1\frac{3}{8}$ inch would be sufficient, as would also $\frac{3}{32}$ by 1 inch.

Methods of Brake Operation. While it is generally thought that round iron rods are the universal means of brake operation, such is not the case. Many brakes on excellent cars are worked, as the illustrations show, by means of cables. This idea is even carried so far that brakes have been fitted to operate through the medium of ropes. Chains of small diameter have also been used, as well as combinations of rods, chains, cables, and ropes.

Fully as important as the operating means, is the matter of equalizing the pull so that the same force is exerted upon both wheels at once. This action is influential in causing side-slip or skidding, which may result fatally. To equalize the force was one reason for the use of cables, although the more up-to-date way is to attach the operating lever to the center of a long bar, to the extremities of which the brakes themselves are fastened. A pull on the bar is then divided up into two different pulls on the brakes, the division being according to their respective needs and automatic as well. This is an important point and one that should be looked after in the purchase of a new car.



SELDEN THIRTY-SIX HORSE-POWER, TORPEDO TYPE, TOURING CAR
The Selden Motor Vehicle Co., Rochester, N. Y.

GLOSSARY OF AUTOMOBILE TERMS

A collection of the more common technical terms used in connection with self-propelled vehicles and aërial navigation.

A

A. A. A. Abbreviation for American Automobile Association.

Abrasive. Any hard substance used for grinding or wearing away other substances.

Absorber, Shock. See *Shock Absorber.*

Acceleration. The rate of change of velocity of a moving body.

Accelerator. An apparatus for changing the speed of the gas-engine governor to allow the engine to speed up.

Accelerator Pedal. The pedal by which the accelerator is operated.

Accessory. A subordinate machine that accompanies or aids a more important machine; as, a horn is an accessory of an automobile.

Accumobile. A term used in Europe in referring to an electric automobile in which a storage battery or accumulator is used to furnish power to an electric motor; an electric vehicle.

Accumulator. A secondary battery or storage battery. It usually consists of chemically prepared lead plates combined with an acid solution. Upon being charged with an electric current from a primary source, a chemical change takes place which enables the plates in their turn to give a current of electricity when used as a source of power; the plates at the same time returning to their original chemical state.

Acetone. A liquid obtained as a by-product in the distillation of wood alcohol, and used in connection with reservoirs for storing acetylene for automobile lights, as it dissolves many times its own volume of acetylene gas.

Acetylated Alcohol. Alcohol which has been denatured by the addition of acetylene, which also increases its fuel value. See *Denatured Alcohol.*

Acetylene. A gaseous hydrocarbide used as an illuminant; is usually generated for that purpose by the action of water on calcium carbide.

Acetylene Generator. A closed vessel in which acetylene gas may be produced by the action of water on calcium carbide and supply the gas under uniform pressure.

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Acetylene Lamp. A lamp which burns acetylene gas.

Acetylite. Calcium carbide which has been treated with glucose. It is used to obtain a more uniform and slower production of acetylene gas than can be obtained with the untreated calcium carbide.

Acid. In connection with automobiles the term usually means the liquid or electrolyte used in the storage battery. See *Electrolyte.*

Acidimeter. An instrument for determining the purity of an acid.

Adhesion. That property of surfaces in contact by virtue of which one of them tends to stick to the other. It is often used as synonymous with friction. The adhesion of wheels acts to prevent slipping.

Adjusting Plane. A smaller plane of an aëroplane, generally placed at the end of the wing tip and adjusted to maintain lateral balance. A *stabilizer* placed at the end of a wing tip.

Adjusting Surface. See *Adjusting Plane.*

Adjustment. The slackening or tightening up of parts to compensate for wear, reduce friction, or secure better contact.

Admission. In a steam engine, the letting in of the steam to the cylinder; in a gas engine, the letting in of the mixture of gas and air to the cylinder.

Admission Line. The part of the indicator diagram which shows the actual condition while the working vapor is entering the cylinder.

Admission Pipe. The pipe by which the fuel is conducted from the carbureter of the gas engine to the admission valve chamber.

Admission Port. The passage by which steam enters the cylinder of the steam engine. Also called *Steam Port.*

Admission Valve. A valve controlling the supply of the working fluid.

Advanced Ignition. Usually called *advancing the spark.* Setting the spark of an internal-combustion motor so that it will ignite the charge at an earlier part of the stroke.

Advance Sparking. A method by which the time of occurrence of the ignition spark may be regulated, by completing the electric circuit at an earlier period.

Advancing Edge. The front edge of any of the surfaces of a heavier-than-air flying machine.

Advancing the Spark. See *Advanced Ignition.*

Advancing Surface. A surface of an aëroplane that is ahead of another surface.

Aërocurve. A word proposed in place of *aëroplane,* as the surfaces are curves rather than planes.

Aërodrome. (1) A tract of land or buildings for the flight or housing of flying machines. (2) The name proposed by Langley for the *aëroplane.*

Aërofoil. A substitute proposed for *aëroplane.*

Aërometer. An instrument to measure the specific gravity of gases. Practically the same as a hydrometer. Usually, however, the aërometer combines a hydrometer with a thermometer.

Aëromobile. Berliner's name for his helicopter.

Aëronat (air swimmer). A term sometimes applied to dirigible balloons.

Aëronaut. An aërial navigator.

Aëronautics. The science or art of navigating the air.

Aëronef. Any heavier-than-air flying machine.

Aëronet (air runner). A name suggested for aëroplane.

Aëroplane. A heavier-than-air flying machine having lateral wings which are comparatively immovable. The term does not define the machine, as the word is applicable only to flat surfaces, while the sustaining surfaces are nearly always curves.

Aërostat. A lighter-than-air flying machine depending upon the use of a volume of gas whose specific gravity is less than that of the air, but having no means of lateral guiding; an ordinary balloon.

Aërostatics. The science of the pressure, weight, and equilibrium of the air and other elastic fluids, and of bodies sustained in them.

Aërostation. Aërial navigation.

After-Burning. Continued burning of the charge in an internal-combustion engine after the explosion.

After-Firing. An explosion in the muffler or exhaust passages.

A-h. Abbreviation for *ampere-hour*.

Aileron. In aëronautics, a small hinged wing tip to maintain lateral balance. It differs from an adjusting plane in that it is capable of being controlled during flight.

Air Bag. In aëronautics, a small bag within a balloon. These bags are connected with an air pump, and by increasing or decreasing the amount of air in the bags the pressure of gas within the balloon may be regulated.

Air Bottle. A metal tank on the automobile for carrying compressed air for tire inflation.

Air-Bound. See *Air-Lock*.

Air-Compressor. A machine for supplying air under pressure for inflating tires, starting the motor, etc.

Air Cooling. A system of dispersing by air-convection the heat generated in the cylinder of an internal-combustion motor.

Air-Feed Pump. A steam-operated pump used to force air under pressure to the burner of a steam boiler.

Air Harbor. One or more buildings for housing airships.

Air Inlet. An opening in a carbureter to admit air.

Air Lock. Stoppage of circulation in the water system caused by a bubble of air lodging in the top of a bend in the pipe.

Air Poise. A device to indicate the weight of the air.

Air Pump. A pump operated by the engine to supply air pressure to the oil tank or gasoline tank; sometimes called *pressure pump*.

Air-Pump Governor. A device to regulate the speed of the air pump so as to give a uniform air pressure.

Air Resistance. The resistance offered by the air to a body in motion. The resistance to a flat surface varies approximately as the square of the velocity.

Air Tube. See *Pneumatic Tire.*

Airless Tire. Name of special make of non-puncturable resilient tire.

Airship. A name applied to any apparatus for aërial navigation. Strictly, should denote only aëronats or dirigible balloons.

A. L. A. M. Abbreviation for Association of Licensed Automobile Manufacturers.

A. L. A. M. Horse-Power Rating. The horse-power rating of an automobile found by the standard horse-power formula approved by the Association of Licensed Automobile Manufacturers. This formula is H. P. = Bore of cylinder (in inches) squared × No. of cylinders ÷ 2.5.

Alarm, Low-Water. See *Low-Water Alarm.*

Alcohol. A colorless, volatile, inflammable liquid which may be used as fuel for internal-combustion engines.

Alcohol, Denatured. Alcohol rendered unfit for drinking purposes by the addition of wood alcohol, acetylene, and other substances.

Alighting Gear. The mechanism on the under part of an aëroplane to cushion its descent and bring it to a stop upon reaching the ground. It usually consists of pneumatic-tired wheels with a spring frame, or of skids, the starting gear and alighting gear nearly always being combined.

A. M. C. M. A. Abbreviation for American Motor-Car Manufacturers Association.

Ammeter. An instrument to measure the value of current in an electric circuit directly in amperes. Also called *ampere-meter.*

Ampere. The practical unit of rate of flow of electric current; measuring the current intensity.

Amperage. The number of amperes, or current strength, in an electric circuit.

Ampere-Hour. A term used to denote the capacity of a storage battery or closed-circuit primary battery. A battery that will deliver three amperes for six hours is said to have an eighteen-ampere-hour capacity.

Ampere-Meter. See *Ammeter.*

Ampere-Second. A term used in place of *Coulomb.*

Anemometer. An instrument for measuring and registering the velocity and direction of the wind. In aëronautics, it is used as well for measuring and registering the velocity of airships.

Angle of Entry. The angle made in a curved aëroplane surface by a tangent to the advancing edge with the line of motion.

Angle of Incidence. The angle made by an aëroplane surface with its line of travel.

Angle of Steering. The sum of the inclination of the two steering arms from the right angle. This is usually between 50 degrees and 60 degrees, giving an inclination for each armof between 25 and 30 degrees.

Angle of Trail. The angle of a tangent to the rear edge of a curved aëroplane surface with the line of travel.

Angle-Iron Underframe. An underframe constructed of steel bars whose cross-section is a right angle.

Annular Gear. A toothed wheel upon which the teeth are formed on the inner circumference.

Annular Valve. A circular valve having a hole in the center.

Annunciator. An installation of electric signals or a speaking tube to allow the passengers in an enclosed car to communicate with the driver.

Anti-Freezing Solution. A solution to be used in the cooling system to prevent freezing in cold weather; any harmless solution whose freezing point is somewhat below that of water may be used.

Anti-Friction Metal. Various alloys of tin and lead used to line bearings, such as babbitt metal, white metal, etc.

Anti-Skid Device. Any device which may be applied to the wheels of a motor car to prevent their skidding, such as tire coverings with metal rivets in them, or chains, etc.

Anti-Vibrator. A mat placed on the floor of the vehicle to do away with the vibration.

Apteroid. An aëronautic term suggested to designate a type of aëroplane wing which is short and broad.

Arch. In aëronautics, a downward curve given the ends of a winged surface.

Armature. A mass of iron or other magnetic material so placed that it may be moved past the pole or poles of the magnet. The armature of a dynamo is that part of a dynamo carrying the conductors in which the differences of potential which cause the current are generated.

Armature Core. The iron core on or around which the armature coils of the dynamo are wound.

Artillery Wheel. A wheel having heavy wooden spokes.

Aspect Ratio. The proportion of the length of a wing or aëroplane surface to the width.

Aspiration. The action of a current of air flowing against the edge of a spiral, curved wing or aëroplane surface, by which the surface is drawn toward the current; also called *tangential force*.

Aspirating Nozzle. An atomizing nozzle to make the liquid passing through it pass from it in the form of a spray.

Atmospheric Line. A line drawn on an indicator diagram at a point corresponding with the pressure of the atmosphere.

Atmospheric Valve. See *Suction Valve*.

Atomizer. A device by which a liquid fuel such as gasoline is reduced to small particles or to a spray; usually incorporated in the carbureter.

Attitude. See *Angle of Incidence*.

Auto. (1) Popular abbreviation for automobile. (2) A Greek prefix meaning *self*.

Auto-Boat. A motor boat.

Auto-Bus. An enclosed motor-driven public conveyance, seating six or more people; usually has a regular route of travel.

Autocar. A motor car or automobile; a trade name for a particular make of automobile.

Auto-Cycle. See *Motorcycle.*

Autodrome. A track especially prepared for automobile driving, particularly for races.

Auto-Igniter. A small magneto generator or dynamo for igniting gasoline engines, the armature of which is connected with the flywheel by gears or by friction wheels, so that electric current is supplied as long as the engine revolves.

Autoist. One who uses an automobile.

Automatic Carbureter. A vaporizer or carbureter for gasoline engines whose action is entirely automatic.

Automatic Ignition. See *Self-Firing.*

Automatic Stability. The maintaining of lateral and longitudinal stability of a flying machine independently of the control of the operator.

Automatic Valve. A valve whose operation is independent of the control of the operator; as, for instance, the automatic boiler-feed regulator of a steamer.

Auto-Meter. Trade name for special make of combined speedometer and odometer.

Automobile. A motor-driven vehicle having four or more wheels. Some three-wheeled vehicles are properly automobiles, but are usually called *tricars.*

Automobilism. Continued use of or fondness for the automobile; the sport and industry connected with automobiles.

Automobilist. The driver or user of an automobile.

Auto-Truck. A motor-driven vehicle for transporting heavy loads; a heavy commercial car.

Auxiliary Air Valve. An extra air valve sometimes provided to supply additional air to the engine on high speeds.

Aviation. The science of dynamic flight by means of heavier-than-air machines.

Aviator. The operator of a heavier-than-air flying machine. Strictly, the form of flying machine

Axle. The spindle with which a wheel revolves or upon which it revolves.

Axle, Dead. An axle which does not turn.

Axle, Floating. A live axle with which the wheels run on dead stubs or ends of tubes which carry the load, so that the axle has no load.

Axle, Live. An axle which turns with the wheel and carries the load.

B

Back Kick. The reversal of direction of the starting crank caused by backfiring.

Back Pressure. The pressure on the opposite side of a piston which offers a resistance to the working stroke of the piston.

Backfiring. An explosion in the cylinder of an internal-combustion engine occurring before the proper time, sometimes causing the engine to be reversed.

Backlash. The play between a screw and nut or between the teeth of a pair of gear wheels.

Baffle Plate. A metal sheet in a steam boiler to prevent priming.

Balance Gear. See *Differential Gear.*

Balancing of Gasoline Engines. Insuring the equilibrium of moving parts to reduce the vibration and shocks.

Balancing Plane. In aëronautics, a surface whose position or angle may be changed to steer or maintain balance.

Balancing Surface. Same as *Balancing Plane.*

Ball-and-Socket Joint. A joint in which a ball is placed within a socket recessed to fit it, permitting free motion in any direction within limits.

Ball Bearing. A bearing in which the rotating shaft or axle is carried upon a number of small steel balls which are free to turn in annular paths, called *races.*

Ball Race. Annular channels for the balls of a ball bearing.

Balladeur Train. A French name for a sliding change-speed gear.

Ballonet. A small gas bag attached to the main envelope of a dirigible balloon to assist in guiding.

Balloon. A lighter-than-air type of flying machine, which depends for its operation upon the difference in the specific gravity of the gas contained within the bag and that of the air; a static flying machine; an aërostat.

Barking. The sound made by the explosions caused by after-firing.

Base-Bearing. Any of the pillow blocks which support the shaft on the chassis.

Battery. A combination of primary or secondary cells, as dry cells or storage cells.

Battery Acid. The electrolyte in a storage battery.

Battery-Charging Plug. Power terminals to which the leads of a storage battery may be connected for charging the battery.

Battery Gauge. (1) Voltmeter or ammeter or volt-ammeter for testing the primary or secondary cells. (2) Hydrometer for testing the specific gravity of the electrolyte in a secondary battery.

Battery Syringe. A syringe used to draw out a part of the electrolyte or solution from a storage battery cell to test its density and specific gravity.

Bearing, Roller. A bearing in which the journal rests upon, and is surrounded by, hardened steel rollers which revolve in a channel or race surrounding the shaft.

Beau de Rochas Cycle. The four-stroke cycle used in most internal combustion engines. This cycle was proposed by M. Beau de Rochas and put into practical form by Dr. Otto. See *Four-Cycle* and *Otto Cycle.*

Belt and Clutch Dressing. A composition to be applied to belts and clutches to prevent them from slipping.

Belt Drive. A method of transmitting power from the engine to the countershaft or jack shaft by means of belts.

Benzine. A petroleum product having a specific gravity between that of kerosene and gasoline. Its specific gravity is between 60 degrees and 65 degrees Baumé.

Berline Body. A limousine automobile body having more than two seats in the back part.

Bevel Gearing. Gears the faces of whose teeth are not parallel with the shaft, but are on a beveled edge of the gear wheel.

B. H. P. An abbreviation for brake horse-power.

Bi-Car. Trade name of special make of motorcycle.

Bicycle. A two-wheeled vehicle propelled by the pedalling of the rider.

Binding Posts. See *Terminals.*

Biplane. An aëroplane having two main supporting surfaces one above the other.

Bleeder. A by-pass in the sight-feed of a mechanical oiling system by which the oil delivered through that feed is allowed to pass out instead of going to the bearing.

Block Chain. A chain used in automobiles, bicycles, etc., of which each alternate link is a steel block.

Blow-Back. The backward rushing of the fuel gas through the inlet valve into the carbureter.

Blow-out. The rupture of both the inner tube and outer casing of a pneumatic tire.

Blow-out Patch. See *Patch, Tire Repair.*

Body. The superstructure of an automobile; the part that resembles and represents the body of a horse-drawn vehicle.

Body-Hangers. Attachments to or extensions of the frame for holding the body of the vehicle. They should be properly called *frame-hangers.*

Boiler. A vessel in which water is evaporated into steam for the generation of power.

Boiler Alarm. See *Low-Water Alarm.*

Boiler Covering. A non-conducting substance used as a covering for boilers to prevent loss of heat by radiation.

Boiler-Feed Pump. An automatic and self-regulating pump for supplying a boiler with feed water.

Boiler-Feed Regulator. A device to make the feed-water supply of the boiler automatic.

Bonnet. (1) The hood or metallic cover over the front end of an automobile. See *Hood.* (2) The cover over a pump-valve box, or a slide-valve casing. (3) A cover to enclose and guide the tail end of a steam-engine-valve spindle or the cover of a piston-valve casing. (4) The pan underneath the engine in an automobile.

Boot. Space provided for baggage at the rear of a car.

Bore. The inside diameter of the cylinder.

Bowden Wire. A wire for transmitting motion by pulling, surrounded by a helical spring for protection.

Boyle's Law of Gases. A law defining the volume and pressure of gases at constantly maintained temperatures. It states that the volume of a gas varies inversely as the pressure so long as the temperature remains the same; or the pressure of a gas is proportional to its density.

Brake. An apparatus for the absorption of power by friction, and by clamping some portion of the driving mechanism to retard or stop the forward motion of the car.

Brake, Band. A brake which contracts upon the outside of a drum attached to some part of the driving mechanism.

Brake, Constricting Band. A form of brake applied by tightening a band around a pulley or drum.

Brake, Double-Acting. A brake which will hold when the drum is rotating in either direction.

Brake, Drum and Band. See *Brake, Band.*

Brake, Expanding Band. A drum brake in which the braking force is exerted by a band forced outward against the inner rim of a pulley.

Brake Horse-Power. The horse-power supplied by an engine as shown by the application of a brake or absorption dynamometer.

Brake, Internal. A brake in which an expanding mechanism is contained within a rotating drum, the expansion bringing pressure to bear on the drum.

Brake Lever. The lever by which the brake is applied to the wheel.

Brake Lining. The wearing surface of a brake; usually arranged to be easily replaced when worn.

Brake Pedal. Pedal by which the brake is applied.

Brake Ratchet. A device by which the brake lever or brake pedal can be set in position and retained there; usually consists of a notched quadrant with which a movable tongue on the lever head or pedal engages.

Brake Rod. The rod connecting the brake lever with the brake.

Brake, Shoe. A brake in which a metal shoe is clamped against a revolving wheel.

Brake, Strap. Another term for band brake.

Breaker Strip. A strip of canvas placed between the tread and body of an outer tire casing to increase the wearing qualities.

British Thermal Unit. The ordinary unit of heat. It is that quantity of heat required to raise the temperature of one pound of pure water one degree Fahrenheit at the temperature of greatest density of water.

Brougham Body. A closed-in automobile body having windows at the side doors, and in front, but with no extension of the roof over the front seat.

B. T. U. Abbreviation for *British thermal unit.*

Buckboard. A four-wheeled vehicle in which the body and springs are replaced by an elastic board or frame.

Buckling. Irregularities in the shape of the plates of storage cells following a too rapid discharge.

Buggyabout. A light motor-driven vehicle having the appearance of the ordinary horse-drawn buggy.

Buggyaut. Trade name for special make of light, buggy-type automobile.

Bumper. A contrivance at the front of the car to minimize shock of collision; it consists of plungers working in tubes and gaining elasticity from springs.

Buoyancy. (1) The upward pressure exerted by a fluid upon a floating body. (2) The power or tendency of a fluid to keep an object afloat in another fluid.

Burner, "Torch" Igniter. A movable auxiliary vaporizer for starting the fire in steam automobile burners.

Bus-Pipe. A manifold pipe.

Buzzer. (1) A name sometimes applied to the vibrator or trembler of a jump-spark ignition coil. (2) A device used in place of a horn, and consisting of a diaphragm which is made to vibrate rapidly by an electromagnet.

By-Pass. A small valve to provide a secondary passage for fluids passing through a system of piping.

C

C. Abbreviation for Centigrade Thermometer Scale.

Calcium Carbide. A compound of calcium and carbon used for the generation of acetylene by the application of water.

Cam. A revolving disk, irregular in shape, fixed on a revolving shaft so as to impart to a rod or lever in contact with it an intermittent or variable motion.

Cam Gear. The gear driving the cam shaft of a gas engine. In a four-cycle engine this is the same as the two-speed gear.

Cam Shaft. A shaft by which the valve cams are rotated; also known as the *secondary shaft.*

Camber. (1) The greatest depth of curvature of a surface. (2) The amount of bend in an axle designed to incline the wheels.

Camber of Spring. The maximum distance between the upper and lower parts of a spring under a given load.

Cambered Frame. A narrowing of the front of a motor car to permit of easier turning.

Canopy. An automobile top that cannot be folded up.

Cape Hood. An automobile top which is capable of either being folded up or extended.

Car. (1) A wheeled vehicle. (2) A large automobile. (3) The box, basket, or cage suspended from a balloon to hold passengers, supplies, etc.

Carbide. See *Calcium Carbide.*

Carbide Feed. A type of acetylene generator in which the calcium carbide is fed into the water.

Carbon Bridge. Formation of soot between points of spark plug.

Carbon Remover. A tool or solution for removing carbon deposits from the cylinder, piston, or spark plug of a gasoline engine.

Carbureter. An appliance for mixing an inflammable vapor with air. It allows air to be passed through or over a liquid fuel and carry off a portion of its vapor mixed with the air, forming an explosive mixture.

Cardan Joint. A universal joint or Hooke's coupling.

Cardan Shaft. A shaft provided with a Cardan joint at each end.

Casing. The shoe or outer covering of a double-tube automobile tire.

Catalytic Ignition. See *Ignition, Catalytic.*

Cell. (1) In aëronautics, a structure having upper, lower, and side surfaces, as a box kite. (2) One of the units of a voltaic battery.

Cellular Radiator. A radiator in which the openings between the tubes are in the form of small cells. The same as a honeycomb radiator.

Cellular Tire. A cushion tire which is divided into compartments or cells.

Center of Effort. See *Center of Thrust.*

Center of Gravity. The point of a body about which all portions are balanced.

Center of Lift. In aëronautics, a mean of all the centers of pressure.

Center of Pressure. In aëronautics, a line along the underside of an aëroplane surface, on either side of which pressures are equal.

Center of Thrust. In aëronautics, a point or line along which the thrust of the propellers is balanced.

Centigrade Scale. The thermometer scale invented by Celsius. Used universally in scientific work.

Century. In automobiling, a hundred-mile run.

C. G. S. System. Abbreviation for centimeter-gram-second system of measurement; the standard system in scientific work.

Chain, Drive. A heavy chain by which the power from the motor may be transmitted to the rear wheels of an automobile.

Chain, Tire. A small chain fastened about the tire to increase traction and prevent skidding.

Chain Wheel. A sprocket wheel for the transmission chains of a motor-driven vehicle.

Change-Speed Gear. See *Gear, Change-Speed.*

Change-Speed Lever. See *Lever, Change-Speed.*

Charles' Law of Gases. See *Gases, Gay Lussac's Law of.*

Charging. The passing of a current of electricity through a storage cell. See *Accumulator.*

Chassis. The frame, springs, wheels, transmission, and all the mechanism of the automobile except the body. In the original French it means only the frame or the frame and springs. See *Running Gear.*

Chauffeur. In America this term means the paid driver or operator of the motor car. The literal translation from the French means *stoker* or *fireman of a boiler.*

Check, Steering. See *Steering Check.*

Check Valve. An automatic or non-return valve used to control the admission of feed water in the boiler, etc.

Circulation Pump. A mechanically operated pump by which the circulation of water in the cooling system is maintained.

Clash Gear. A sliding change-speed gear.

Clearance. (1) The distance between the road surface and the lowest part of the under-body of an automobile. (2) The space between the piston of an engine when at the extremity of its stroke, and the head of the cylinder.

Clearance Space. The space left between the end of the cylinder and the piston plus the volume of the ports between the valves and the cylinder.

Clincher Rim. A wheel rim having a turned-in edge on each side, forming channels. Into this the edge or flange of the tire fits, the air pressure within locking the tire and rim together.

Clincher Tire. A pneumatic tire designed to fit on a clincher rim.

Clutch. A device for engaging or disconnecting two pieces of shafting so that they revolve together or run free as desired.

Clutch Lining. The wearing surface of a clutch. This may be easily removed and replaced when worn.

Clutch Spring. A spring arranged to either hold a clutch out of gear or throw it into gear.

Cock, Priming. A small cock, usually operated by a lever, for admitting gasoline to the carbureter to start its action.

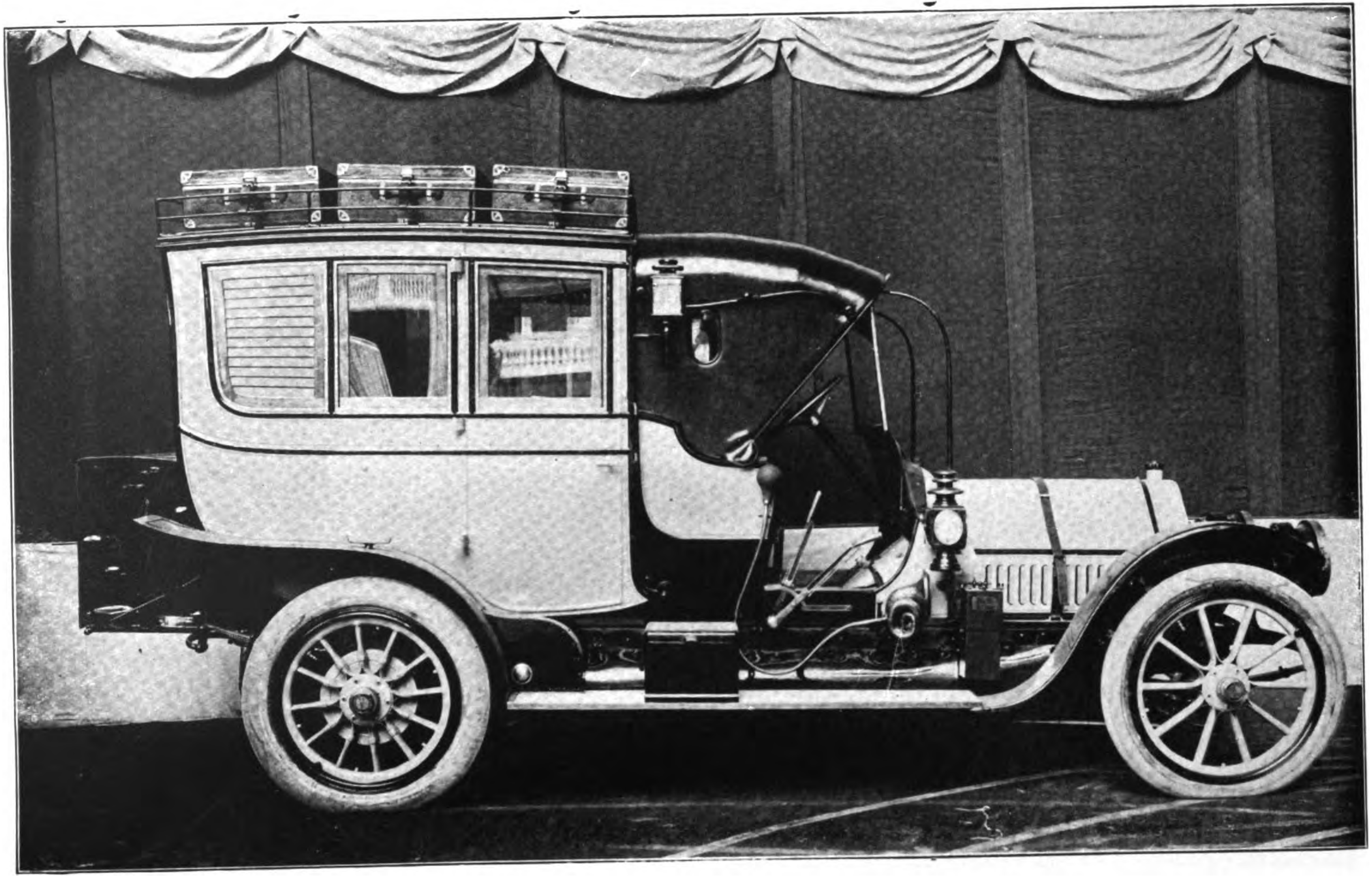
Coil, Non-Vibrator. A coil so designed that it will supply a sufficient spark for the ignition with one make and break of the primary circuit.

Coil, Spark. See *Spark Coil.*

Coil Vaporizer. An auxiliary vaporizer to assist in starting a steam boiler. It is a coil of tubing into which liquid gasoline is admitted and burned to start the generation of gas in the main burner.

Combustion Chamber. That part of an explosive motor in which the gases are compressed and then fired, usually by an electric spark.

Commercial Car. A motor-driven vehicle for commercial use, such as transporting passengers or freight.



AUTOMOBILE COACH, ENGLISH TYPE

Commutator. In the ignition system of an explosive motor, the commutator is a device to automatically complete the circuit of each of a number of cylinders in succession.

Commutator of Dynamo or Motor. That part of a dynamo which is designed to cause the alternating current produced in the armature to flow in one direction in the external circuit; in a motor, to change the direct current in the external circuit into alternating current.

Compensating Carbureter. An automatic attachment to a carbureter, controlling either air or fuel admission, or both, so that the proportion of one to the other is always maintained under any variation of power required.

Compensating Gear. See *Differential Gear.*

Compensating Joint. See *Universal Joint.*

Compound Control. In aëronautics, a controlling system in which two separate operations are obtained by the movement of a single lever or steering wheel in two directions.

Compound Engine. A multiple-expansion steam engine in which the steam is expanded in two stages, first in the high-pressure cylinder, and then in the low-pressure cylinder.

Compression. (1) That part of the cycle of a gas engine in which the charge is compressed before ignition; in a steam engine it is that phase of the cycle in which the pressure is increased due to compression of the exhaust steam behind the piston. (2) The greatest pressure exerted on the gas in the compression chamber.

Compression Chamber. The clearance volume above the piston in a gas engine, also called *Compression Space.*

Compression Cock. See *Compression-Relief Cock.*

Compression Line. The line on an indicator diagram corresponding to the phase of the cycle in which the gas is compressed.

Compression-Relief Cock. A small cock by which the compression chamber of an internal-cumbustion motor may be opened to the air and thus allow the compression in the cylinder to be relieved to facilitate turning by hand, or *cranking.*

Compression Space. See *Compression Chamber.*

Compression Tester. A small pressure gauge by which the degree of compression of the mixture in a gas-engine cylinder may be tested.

Compressor, Air-. See *Air-Compressor.*

Condenser. In a steam motor, an apparatus in which the exhaust steam is converted back into water. (2) A device for increasing the electric capacity of a circuit. Used in an ignition circuit to increase the strength of the spark.

Cone Bearing. A shaft bearing in which the shaft is turned to a taper and the journal turned to a conical or taper form.

Cone Clutch. A friction clutch in which there are two cones, one fitting within the other.

Connecting Rods. The part of an engine connecting the piston to the crank, and by means of which a reciprocating motion of the piston is converted into the rotary motion of the crank.

Constricting Band Brake. See *Brake, Constricting Band.*

Constricting Clutch. A friction clutch in which a band is tightened around a drum to engage it.

Contact-Breaker. A device on some forms of gasoline motors having an induction coil of the single jump-spark type, to open and close the electric circuit of the battery and coil at the proper time for the passage of the arc or spark at the points of the spark plug.

Contact-Maker. See *Contact-Breaker.*

Continental Drive. Double-chain drive.

Control, Throttle. Method of governing the power of the engine by altering the area of the passage leading to the admission valve so that the amount of the fuel introduced into the cylinder is varied.

Control, Spark. Method of controlling the power of an engine by varying the point in the stroke at which ignition takes place.

Controller, Electric. Apparatus for securing various combinations of storage cells and of motors so as to vary the speed of the car at will.

Converter. A device for changing alternating current into direct current for charging storage batteries, etc. Converters may be any of three kinds: rotary, electrolytic, or mercury-vapor. The mercury-vapor converter is most widely used.

Convertible Body. An automobile body which may be used in two or more ways, usually either as an open or closed carriage, or in which several seats may be concealed, and raised to increase the seating capacity.

Cooling Fan. Fan used in automobiles to increase the current of air circulating around the cylinders, or through the radiator.

Coulomb, The. The unit of measure of electrical quantity. Sometimes called *Ampere-Second.* It is equivalent to the product of the current in amperes by the number of seconds current has been flowing.

Countershaft. An intermediate or secondary shaft in the power-transmission system.

Coupling, Flexible. See *Universal Joint.*

Crank. A lever designed to convert reciprocating motion into rotating motion or *vice versâ;* usually in the form of a lever formed at an angle with the shaft, and connected with piston by means of connecting rod.

Crank Case. The casing surrounding the crank end of the engine.

Crank-Case Explosion. Explosion of unburned gases in the crank case.

Crank Chamber. The enclosed space of small engines in which the crank works.

Crank Pin. The pin by which the connecting rod is attached to the crank.

Crank Shaft. The main shaft of an engine.

Crank, Starting. A handle made to fit the projecting end of the crank shaft of a gas engine so that the engine may be started to revolving by hand.

Cranking. The act of rotating the motor by means of a handle in order to start it. Turning the flywheel over a few times causes the engine to take up its cycle, and after an explosion it continues to operate.

Creeping of Pneumatic Tires. The tendency of pneumatic tires to push forward from the ground and thus around the rim, in the effort to relieve and distribute the pressure.

Crypto Gear. See *Planetary Gear.*

Crystallization. The rearrangement of the molecules of metal into a crystalline form under continued shocks. This is often the cause of the breaking of the axles and springs of a motor car.

Cup, Priming. A small cup-shaped device provided with a cock, by which a small quantity of gasoline can be introduced into the cylinder of a gasoline engine.

Curtain. In aëronautics, the same as *panel.*

Current. The rate of flow of electricity; the quantity of electricity which passes per second through a conductor or circuit.

Current Breaker. See *Contact Breaker.*

Current Indicator. A device to indicate the direction of current flow in a circuit; a polarity indicator.

Current Rectifier. A device for converting alternating current into direct current. See *Converter.*

Cushion Tire. See *Tire, Cushion.*

Cut-Off, Gas Engine. That point in the cycle of an internal-combustion engine at which the admission of the mixture is discontinued by the closing of the admission valve.

Cut-Off, Steam Engine. That point in the cycle of a steam engine, or that point on an indicator diagram at which the admission of steam is discontinued by the closing of the admission valve.

Cut-Out, Muffler. A device by which the engine is made to exhaust into the air instead of into the muffler.

Cut-Out Pedal. Pedal by means of which the engine is made to exhaust into the air instead of into the muffler.

Cycle. A complete series of operations beginning with the drawing in of the working gas, and ending after the discharge of the spent gas.

Cycle, Beau de Rochas. See *Beau de Rochas Cycle.*

Cylinder. A part of a reciprocating engine consisting of a cylindrical chamber in which a gas is allowed to expand and move a piston connected to a crank.

Cylinder Cock. A small cock used to allow the condensed water to be drained away from the cylinder of a steam engine, usually called a *drain cock.*

Cylinder Head. The cover of the cylinder of a steam engine.

Cylinder Jacket. See *Jacket, Water.*

D

Dash. The upright partition of a car in front of the front seat and just behind the bonnet.

Dash Coil. An induction coil for jump-spark ignition, having an element for each cylinder with dash connections to the commutator on the engine or cam shaft.

Dash Gauge. A steam, water, oil, air, or electric gauge placed upon the dash of the car.

Day Type of Engine. The two-cycle internal-combustion engine with an air-tight crank case.

Dead Axle. See *Axle, Dead.*

Decarbonizer. See *Carbon Remover.*

Deck. In aëronautics, a main surface of an aëroplane.

Demountable Rim. A rim upon which a spare tire may be mounted and carried, and so arranged that it may be easily and quickly taken off or put on the wheel.

Denatured Alcohol. See *Alcohol, Denatured.*

Densimeter. See *Hydrometer.*

Depolarizer. Material surrounding the negative element of a primary cell to absorb the gas which would otherwise cause polarizing.

Derrick. In aëronautics, a tower from the top of which a weight is allowed to fall to start an aëroplane.

Detachable Body. A body which may be detached from and placed upon the chassis.

Detachable Rim. See *Demountable Rim.*

Diagram, Indicator. See *Indicator Card.*

Diagram, Jeantaud. A diagrammatic representation of the running gear of an automobile, showing it turning corners of various radii for the purpose of determining the front-axle and steering connections.

Diesel Gas Engine. Four-cycle internal-combustion engine in which the explosion of the charge is accomplished entirely by the temperature produced by the high compression of the mixture.

Differential, Bevel-Gear. A balance gear in which the equalizing action is obtained by means of bevel gears.

Differential Gear. A mechanism to permit driving the wheels and yet allow them to turn a corner without slipping. An arrangement such that the driving wheels may turn independently of each other on a divided axle, both wheels being under the control of the driving mechanism. Sometimes called *balance, compensating,* or *equalizing, gear.*

Differential, Spur-Gear. A differential gear, in which the equalizing action is obtained by spur gears.

Dihedral. In aëronautics, upward inclination of winged parts at an angle to each other.

Direction Indicator. A polarity indicator to show the direction of current flow in an ignition circuit.

Dirigible. Steerable; drivable; usually applied to lighter-than-air flying machines which may be propelled and guided.

Disk Clutch. A clutch in which the power is transmitted by a number of thin plates pressed face to face.

Distance Rod. See *Radius Rod.*

Distribution Shaft. See *Cam Shaft.*

Distributor, Spark. See *Commutator.*

Doctor's-Cab Body. An automobile body especially adapted for the use of doctors, resembling the body of a hansom cab, with entrance from the front and at the left side of the front. Another type is a two-seated brougham with no front seat, the control and steering mechanism being enclosed.

Double Monoplane. A monoplane having two double surfaces, one behind the other.

Drift. In aëronautics, the resistance of an aëroplane surface to forward movement.

Drive Shaft. The shaft transmitting the motion from the change gears to the driving axle; the torsion rod.

Driving Axle. The axle of a motor car through which the power is transmitted to the wheels.

Driving Wheel. The wheel to which or by which the motion is transmitted.

Drome. Word suggested for the flight of aëroplanes.

Dry Battery. A battery of one or more dry cells.

Dry Cell. A primary voltaic cell in which a moist material is used in place of the ordinary fluid electrolyte.

Dual Ignition. The use of two separate systems of ignition.

Dynamo. The name frequently applied to a dynamo-electric machine used as a generator. Strictly, the term *dynamo,* should be applied to both motor and generator.

Dynamometer. The form of equalizing gear attached to a source of power or a piece of machinery to ascertain the power necessary to operate the machinery at a given rate of speed and under a given load.

E

Earth. See *Ground.*

Economizer, Gas. An appliance to be attached to a float-feed carbureter to improve the mixture by automatically governing the amount of air in the float chamber.

Eccentric. A disk mounted off-center on a shaft to convert rotary into reciprocating motion.

Economy, Fuel. The fuel economy of a motor is the relation between the heat units in the fuel used in the motor and the work or energy given out by the motor.

Efficiency. The efficiency of a gasoline motor is the relation between the heat units consumed by the motor and the work or energy in foot pounds given out by it. Electrical efficiency of a motor is the relation between the electrical energy put into the motor and the mechanical energy given out by it.

Ejector. An apparatus by which a jet of steam propels a stream of water in almost the same way as an injector, except that the ejector delivers it into a vessel having but little pressure in it.

Electric Generator. A dynamo-electric machine in which mechanical energy is transformed into electrical energy; usually called *dynamo.*

Electric Horn. An automobile horn electrically operated.

Electric Motor. A dynamo-electric machine in which electrical energy is transformed into mechanical energy.

Electric Vehicle. An automobile propelled by an electric motor, for which current is supplied by a storage battery carried in the vehicle.

Electrolyte. A compound which can be decomposed by electric current. In referring to storage batteries, the term *electrolyte* means the solution of sulphuric acid in water in which the positive and negative plates are immersed.

Electromobile. An electric vehicle.

Electromotive Force. A tendency to cause a current of electricity to flow; usually synonymous with *potential, difference of potential, voltage,* etc.

Elevator. In aëronautics, a horizontal rudder for steering upwards or downwards.

Emergency Brake. A brake to be applied when a quick stop is necessary; usually operated by a pedal or lever.

Engine, Alcohol. An internal-combustion engine, in which a mixture of alcohol and air is used as fuel.

Engine, Gasoline. An internal-combustion motor in which a mixture of gasoline and air is used as fuel.

Engine, Kerosene. An internal-combustion engine in which a mixture of kerosene and air is used as fuel.

Engine Primer. A small pump to force fuel into the carbureter.

Engine Starter. An apparatus by which a gasoline engine may be started in its cycle of operations without use of the starting crank. It belongs usually to one of four classes: (1) mechanical or spring-actuated, such as a coil spring wound up by the running of the engine or a strap around the flywheel; (2) fluid pressure, such as compressed air or exhaust gases induced into the cylinder to drive the piston through one cycle; (3) the electric system, in which a small motor is used to turn the engine over; (4) combinations of these.

Engine, Steam. A motor in which the energy in steam is used to do work by moving the piston in a cylinder.

Epicyclic Gear. See *Planetary Gear.*

Equalizing Gear. See *Differential Gear.*

Exhaust Horn. An automobile horn in which the sound is produced by the exhaust gases.

Exhaust Lap. The extension of the inside edges of a slide valve to give earlier closing of the exhaust. Also called *inside lap*

Exhaust Manifold. A large pipe into which the exhaust passages from all the cylinders open.

Exhaust Port. The opening through which the exhaust gases are permitted to escape from the cylinder.

Exhaust Steam. Steam which has given up its energy in the cylinder and is allowed to escape.

Exhaust Stroke. The stroke of an internal-combustion motor during which the burned gases are expelled from the cylinder.

Exhaust Valve. A valve in the cylinder of an engine through which the exhaust gases are expelled.

Expanding Clutch. A clutch in which a split pulley is expanded to press on the inner circumference of a ring which surrounds it, and thus transmit motion to the ring.

Expansion, Gas Engine. That part of the cycle of a gas engine immediately after ignition, in which the gas expands and drives the piston forward.

Expansion, Steam Engine. That portion of the stroke of the steam engine in which the steam supply is cut off by the valves and continues to perform work on the piston, increasing in volume and decreasing in pressure.

Explosive Motor. See *Internal-Combustion Motor.*

F

Fan, Cooling. A mechanically operated fan for producing a current of air for cooling the radiator or cylinders of a gas engine.

Fan, Radiator. A mechanically operated rotary fan used to induce the flow of air through the radiator to facilitate the cooling of the water.

Fat Spark. A short, thick, ignition spark.

Feathering. In aëronautics, the movement of surfaces so that they pass edgewise through the air in one direction and flatwise through the air in the other.

Feed Regulator. A device to maintain a uniform water level in a steam boiler by controlling the speed of the feed pump.

Feed-Water Heater. An apparatus for heating the boiler-feed water, either by means of a jet of steam or steam-heated coils.

Fender. A mud guard or shield over the wheels of a car.

Fierce Clutch. A clutch is called *fierce* when it releases with difficulty.

Fin. (1) In aëronautics, a fixed vertical immovable surface for maintaining lateral stability. (2) Projections cast on the cylinder of a gas engine to assist in cooling.

Firing. (1) Ignition of the charge in a gas engine. (2) The act of furnishing fuel under the boiler of a steam engine.

Flash Boiler. A boiler arranged to generate highly superheated steam almost instantaneously, by allowing water to come in contact with very hot metal surfaces.

Flash Generator. See *Flash Boiler.*

Flash Point. The temperature at which an oil will give off a vapor that will ignite when a flame comes in contact with it.

Flexible Coupling. See *Universal Joint.*

Flexible Propeller. In aëronautics, a propeller whose fabric is rather loosely mounted on a framework so that it can change its form with the varying air pressures.

Flexible Shaft. A pliant shaft which will transmit considerable power when revolving.

Flexible Tubing. A tube for the conduction of liquids or gases, which may be bent at a small radius without leaking.

Float Carbureter. A carbureter for gasoline engines in which a float of cork or hollow metal controls the height of the liquid in the atomizing nozzle. Sometimes called *float-feed carbureter.*

Float Valve. An automatic valve by which the admission of a liquid into a tank is controlled through a lever attached to a hollow sphere which floats on the surface of the liquid and opens or closes the valve accordingly as it is high or low.

Floating Axle. See *Axle, Floating.*

Floating the Battery on the Line. Charging the battery while it is giving out current.

Flushing Pin. In a float feed carbureter, a pin arranged to depress the float in priming. Also called *primer* and *tickler.*

Flyabout. Name of a special make of roadster.

Flying Angle. In aëronautics, the angle of incidence of aëroplane surfaces in flight.

Flying Attitude. See *Flying Angle.*

Flying Machine. An apparatus designed to enable persons to move about at will through the air. Strictly, the term should be applied to only that class of machines in which human flight is obtained by means of flapping wings.

Flywheel. A wheel upon the shaft of an engine which, by virtue of its moving mass, stores up the energy of the gas transmitted to the flywheel during the impulse stroke and delivers it during the rest of the cycle, thus producing a fairly constant torque.

Foaming. See *Priming.*

Following Edge. In aëronautics, the rear edge of an aëroplane surface.

Following Surface. In aëronautics, a main surface that is preceded by another.

Foot-Brake. A brake to be applied through a pedal.

Fore-and-Aft Stability. See *Longitudinal Stability.*

Fore-Carriage. A self-propelled vehicle in which the motor is carried on the forward trucks, and propelling and steering is done with the forward trucks.

Four-Cycle or Four-Stroke Cycle. The cycle of operations in gas engines occupying two complete revolutions or four strokes.

Frame. The framework or foundation of the car.

Frame-Hangers. See *Body-Hangers.*

Free Wheel. A wheel so arranged that it can rotate more rapidly than the mechanism which drives it.

Friction. The resistance existing between two bodies in contact which tends to prevent their motion on each other.

Friction Clutch. A device for coupling and disengaging two pieces of shafting while in motion, by the friction of cones or plates on one another.

Friction Disk. The thin plate used in a disk or friction clutch. See *Disk Clutch.*

Friction Drive. A method of transmitting power or motion by frictional contact.

Fuel Economy. See *Economy, Fuel.*

Fuel-Feed Regulator. A device in the fuel system of a steam motor by which the rate of flow of fuel to the burner is automatically regulated.

Fuel-Level Indicator. An instrument either permanently connected to the fuel tank or which may be inserted therein to indicate the quantity of fuel in the tank.

Fuselage. In aëronautics, the framework of a flying machine. It applies more particularly to the framework of aëroplanes.

Fusible Plug. A hollow plug filled with an alloy which melts at a point slightly above the temperature of the steam in a boiler, as when the water runs low, thus putting out the fire and preventing burning out the boiler.

G

Gap. (1) In aëronautics, the vertical distance between two adjacent surfaces. (2) In automobiles, the spark gap.

Garage. A building for storing automobiles.

Garage, Portable. A garage which may be moved from one place to another, either as a whole or in sections.

Gas. Matter in a fluid form which is elastic and has a tendency to expand indefinitely with reduction in pressure.

Gas Bag. (1) A gas-tight bag designed to contain gas, usually applied to the envelope of a balloon. (2) In some gas lamps, a receptacle for the gas.

Gas Economizer. See *Economizer.*

Gas Engine. An internal-combustion motor in which a mixture of gas and air is used as fuel. The term is also applied to the gasoline engine.

Gas Engine, Otto. A four-stroke-cycle engine developed by Otto and using hot-tube method of ignition.

Gas Generator. An apparatus in which a gas is generated for any use.

Gas Lamp. See *Acetylene Lamp.*

Gases, Boyle's Law of. See *Boyle's Law of Gases.*

Gases, Gay Lussac's Law of. Called *Charles' Law* and the *Second Law of Gases.* Law defining the physical properties of gases at constantly maintained pressure. It states that at constant pressure the volume of gas varies with the temperature, the increase being in proportion to the change of temperature and volume of the gas.

Gases, Joule's Law of. Statement of the physical properties of gases; that the work-producing or dynamic property of a gas depends alone upon its temperature.

Gasket. A thin sheet of packing material or metal used in making joints, piping, etc.

Gasoline. A highly volatile fluid petroleum distillate; a mixture of fluid hydro-carbons.

Gasoline Engine. An internal-combustion motor in which a mixture of gasoline and air is used as a fuel.

Gasoline Primer. The valve on the carbureter of a gasoline engine by which the action of the engine can be started.

Gasoline-Tank Guage. A fuel-lever indicator for gasoline.

Gasoline Tester. A hydrometer by which the specific gravity of gasoline, and therefore its purity, may be ascertained.

Gauge. Strictly, a measure of, or instrument to determine, dimensions or capacity. Practically, the term refers to an instrument for indicating the pressure or level of liquids, etc.

Gauge Cock. A small cock by which a pipe leading to a gauge may be opened or closed.

Gauge Lamp. Lamp, usually electric, placed above or near the gauges to enable them to be read at night.

Gay Lussac's Law of Gases. See *Gases, Gay Lussac's Law of.*

Gear, Balance. See *Differential Gear.*

Gear Box. The case covering the change-speed gears.

Gear, Change-Speed. An arrangement of gear wheels which transmits the power of the motor to the differential gear at variable speeds independently of the motor speed.

Gear, Differential. See *Differential Gear.*

Gear, Internal. A gear whose teeth project inward toward the center from the circumference of the gear wheel

Gear-Shift Lever. A lever by which the change-speed gears are shifted.

Generator, Acetylene. See *Acetylene Generator.*

Generator, Electric. See *Electric Generator.*

Generator, Steam. A steam boiler.

Generator Tubing. Tubing by which acetylene is conducted from the generator to the lamp.

Gimbal Joint. A form of universal joint.

Glider. An aëroplane without motor or propeller for use in gliding.

Gliding. In aëronautics, the combination of forward and downward movement of an aëroplane without power.

Gliding Angle. In aëronautics, the smallest angle at which an aëroplane is able to glide.

Gong. A loud, clear-sounding bell usually operated either electrically or by foot power.

Governor. A device for automatically regulating the speed of an engine.

Governor, Dynamo. A method of automatic control of the generator (usually an ignition generator, in automobile work) by which its speed is maintained approximately constant.

Governor, Spark. A method of automatically controlling the speed of the engine by varying the time of ignition. See *Governor.*

Grademeter. An instrument for indicating the degree of the gradient or the percent of the grade. It consists of a level with a graduated scale.

Graphite. One of the forms in which carbon occurs in matter. Also known as *black lead* and *plumbago.* Used as a lubricant in powdered or flake form in the cylinders of exlposive engines.

Gravity. The attraction between the earth and bodies on or near it which tends to decrease the distance between the centers of such bodies and the center of the earth.

Gravity-Feed Oiling System. See *Lubrication, Gravity.*

Grease and Oil Gun. A syringe by means of which grease or oil may be introduced into the bearings of the machinery.

Grinding Valves. See *Valve, Grinding.*

Ground. An electric connection with the earth, or to the framework of a machine.

Ground Attitude. In aëronautics, the angle of incidence of an aëroplane surface with the machine on the ground.

Gyroplane. In aëronautics, a heavier-than-air flying machine lifted by rotating aëroplanes; a helicopter.

Gyroscopic Effect. That property of a rotating body by virtue of which it tends to maintain its plane of rotation against all disturbing forces.

H

Half-Motion Shaft. See *Half-Time Shaft.*

Half-Time Shaft. The cam shaft of a four-cycle gas engine. It revolves at one-half the speed of the crank shaft.

Hammer Break. A make-and-break ignition system in which the spark is produced when the moving terminal strikes the stationary terminal like a hammer.

Hangar. Building used for harboring airships. Synonymous with *Air-Harbor.*

Head Resistance. In aëronautics, the resistance of a surface to movement through the air.

Heater, Automobile. A device for warming the interior of an automobile; usually electrical, or by means of exhaust gases or jacket water.

Heavier-Than-Air. In aëronautics, applied to dynamic flying machines which weigh more than the air they displace.

Helicopter. From *helix,* a screw. A dynamic, heavier-than-air flying machine which is sustained by the effect of screws or propellers mounted on vertical axes and rotating in a horizontal plane.

High-Tension Current. A current of high voltage; as the current induced in the secondary circuit of a spark coil.

Honeycomb Radiator. A radiator consisting of many very thin tubes, giving it a cellular appearance.

Hood. That part of the automobile body which covers the frame in front of the dash. The engine is usually placed under the hood.

Hooke's Coupler. See *Universal Joint.*

Horizontal Motor. A motor the center line of whose cylinder lies in a horizontal plane.

Horizontal Rudder. In aëronautics, a rudder placed horizontally for steering in a vertical plane.

Horn, Automobile. A whistle or horn for giving warning of the approach of the automobile.

Horse-Power. The rate of work or energy expended in a given time by a motor. One horse-power is the rate of work or energy expended in raising a weight of 550 pounds one foot in one second, or raising 33000 pounds one foot in one minute.

Hot-Head Ignition. The method of igniting the charge in a gas-engine cylinder by maintaining the head of the combustion chamber at a high temperature from the internal heat of combustion, as in the Diesel engine.

Hot-Tube Ignition. An ignition device formerly used for gas engines, in which a closed metal tube is heated red hot by a Bunsen flame. When the compressed gases in the cylinder are allowed to come in contact with this, ignition takes place.

Hovering. In aëronautics, that method of flight in which a practically fixed position in the air is held.

H. P. (1) Abbreviation for horse-power. (2) Abbreviation for high-pressure.

Hydrocarbons. Chemical combinations of carbon and hydrogen in varied proportions, usually distillates of petroleum, such as gasoline, kerosene, etc.

Hydrometer Scale, Baume's. An arbitrary measure of specific gravity.

Hydrometer. An instrument by which the specific gravity or density of liquids may be ascertained.

I

Igniter. An insulated contact plug without sparking points, used in make-and-break ignition with low-tension magneto.

Igniter, High-Speed. An igniter having a short spark coil for high-speed engines.

Igniter, Jump-Spark. A system of ignition in which is used a current of high pressure, which will jump across a gap in the high-pressure circuit, causing a spark at the gap.

Igniter, Lead of. Amount by which the ignition is advanced. See *Advanced Ignition.*

Igniter, Primary. The apparatus in a primary circuit for making and breaking the circuit.

Igniter Spring. A spring to quickly break the circuit of a primary igniter.

Ignition, Advancing. See *Advanced Ignition.*

Ignition, Catalytic. Method of ignition for explosive motors based on the property of some metals, particularly spongy platinum, of becoming incandescent when in contact with coal gas or carbonized air.

Ignition, Hot-Head. See *Hot-Head Ignition.*

Ignition, Primary. An ignition system in which a low-tension current flows through a primary coil, the circuit being mechanically opened, allowing a high-tension spark to jump across the gap. See *Primary Coil.*

Ignition, Retarding. Setting the spark of an internal-combustion motor so that the ignition will occur at a later part of the stroke.

Ignition, Timing of. The adjustment of the ignition system so that ignition will take place at the desired part of the cycle.

I. H. P. Abbreviation for indicated horse-power.

Indicated Horse-Power. The horse-power of an engine as ascertained from an indicator diagram.

Indicator. An instrument by which the working gas in an engine records its working pressure.

Indicator Card. A figure drawn by means of an indicator by the working gas in an engine. Also called *Indicator Diagram.*

Inflammation. The act or period of combustion of the mixture in the cylinder.

Inflator, Mechanical Tire. A small power-driven air-pump for inflating the tire; either driven by gearing, chain, or belt from the engine shaft, or by friction from the flywheel.

Injector. A boiler-feeding device in which the momentum of a steam jet directed by a series of conical nozzles, carries a stream of water into the boiler, the steam condensing within and heating the water which it forces along.

Inner-Tire Shoe. A piece of leather or rubber to be placed within the tire to protect the inner tube.

Inner Tube. A soft air-tight tube of nearly pure rubber which fits within a felloe upon the casing.

Inside Lap. See *Exhaust Lap.*

Intake Manifold. The large pipe which supplies the smaller intake pipes from each cylinder of a gas engine.

Intensifier. See *Outside Spark Gap.*

Intermediate Shaft. See *Shaft, Intermediate.*

Internal-Combustion Motor. Any prime mover in which the energy is obtained by the combustion of the fuel within the cylinder.

Internal Gear. See *Gear, Internal.*

Interrupter. See *Vibrator.*

J

Jack. A mechanism by which a small force exerted through a comparatively long period of time is enabled to raise a heavy body. Used for raising the automobile axle to remove the weight from the wheels.

Jacket Water. The cooling water circulating in a water-cooling system.

Jeantaud Diagram. See *Diagram, Jeantaud.*

Joint, Knuckle. See *Swivel Joint.*

Joule's Law of Gases. See *Gases, Joule's Law of.*

Jump Spark. A spark produced by a secondary jump-spark coil.

Jump-Spark Circuit Maker. A mechanically operated switch by which the circuit in a jump-spark ignition system is opened and closed.

Jump-Spark Coil. An electrical transformer and interrupter consisting of a primary winding of a few turns of coarse wire surrounding an iron core, and a secondary winding consisting of a great number of turns of very fine wire. The condenser is usually combined with this. Also known as *secondary spark coil.*

Jump-Spark Igniter. See *Igniter, Jump-Spark.*

Jump-Spark Plug. See *Spark Plug.*

K

Keel. In aëronautics, the underframing placed longitudinally under flying machines to stiffen the structure. More usually employed in dirigible balloons.

Kerosene. A petroleum product having a specific gravity between 58° and 40° Baumé. It is used as a fuel in internal-combustion engines and can often be used in gasoline engines by starting the engine on gasoline, then switching to kerosene.

Kerosene Burner. A burner especially adapted to use kerosene as a fuel.

Kerosene Engine. An engine using kerosene as fuel.

Knuckle Joint. See *Swivel Joint.*

L

Lamp Lighter. An apparatus for lighting gas lamps by electricity. The lamps are usually so arranged that by pushing the button the gas is turned on and the spark made at the same time.

Landaulet Body. An automobile body resembling a limousine body, but having a cover fitted to the back which may be let down, leaving the back open. The top generally extends over the driver.

Landing Area. In aëronautics, a specially prepared surface for the alighting of flying machines.

Lap, of Steam Valves. In the slide valve of a steam engine, the amount by which the admission edges overlap the steam port when the valve is central with the cylinder case.

Lateral Stability. In aëronautics, stability in a lateral direction, or from side to side.

Lead of Igniter. See *Igniter, Lead of.*

Lead of Valve. In an engine, the amount by which the admission port is opened when the piston is at the beginning of the stroke; according as this is greater or less, the admission of working fluid is varied through several fractions of the stroke.

Leeway. In aëronautics, movement at right angles to the course being steered, caused by the lateral drift of the atmosphere.

Lever, Brake. See *Brake Lever.*

Lever, Change-Speed. Lever by which the different combinations of change gears are made so as to vary the speed of the driving wheels in relation to the speed of the engine; also called *gear-shift lever.*

Lever Lock. An arrangement for locking the gear-shift lever in the free position so that with the engine running the driving axle will not be driven.

Lever, Spark. Lever by which the speed and power of the engine are controlled by adjusting the time of ignition.

Lever, Steering. See *Steering Lever.*

Lever, Throttle A lever by which the speed and power of the engine are controlled by adjusting the amount of mixture admitted to the cylinder.

Lift. In aëronautics, the sustaining effect of a wing surface or aëroplane surface.

Lifting Jack. See *Jack.*

Lighter-Than-Air. In aëronautics, applied to an airship weighing less than the air displaced by it.

Lighting Outfit, Auto Electric. An outfit for electrically lighting an automobile. This usually consists of a dynamo, storage battery, and lamps and switchboard, with the necessary wiring and cutouts.

Limousine Body. An enclosed automobile body having the front and sides with side doors. The top extends over the seat of the driver.

Link Motion. In a steam engine, the name for the arrangement of eccentric rods, links, hangers, and rocking shafts by which the relative motion and position of the slide valves are changed at will, providing for varying rates of expansion of the steam, and thus varying the speed for either forward or backward motion.

Live Axle. See *Axle, Live.*

Lock, Auto Safety. A device arranged so that it is impossible to start the motor car except by the proper combination or key.

Lock Nut. A nut placed on a bolt immediately behind the main nut to keep the main nut from turning.

Lock Switch. A switch in the ignition circuit so arranged that it cannot be thrown on except by the use of a key.

Lock Valve. A valve capable of being secured with lock and key.

Longitudinal Stability. Stability in the longitudinal direction.

Low-Water Alarm. An automatic arrangement by which notice is given that the water in the boiler is becoming too low for safety.

Lubricant. An oil or grease used to diminish friction in the working parts of machinery.

Lubrication. To supply to moving parts and their bearings grease, oil, or other lubricant for the purpose of lessening friction.

Lubrication, Force-Feed. Method of lubricating the moving parts of an engine by forcing the oil to the points of application by means of a pump.

Lubrication, Gravity. Method of supplying oil to moving parts of an engine by having a reservoir at a certain height above the lowest point to be lubricated and allowing the oil to flow to the points of application by gravity.

Lubrication, Sight-Feed. System of lubrication in which the oil pipe to different points of application is lead through a glass tube in plain sight; usually at a point on the dashboard.

Lubrication, Splash. Method of lubricating an engine by feeding oil to the crank case and allowing the lower edge of the connecting rod to splash into it.

Lubricator. A device containing and supplying oil or grease in regular amounts to the working parts of the machine.

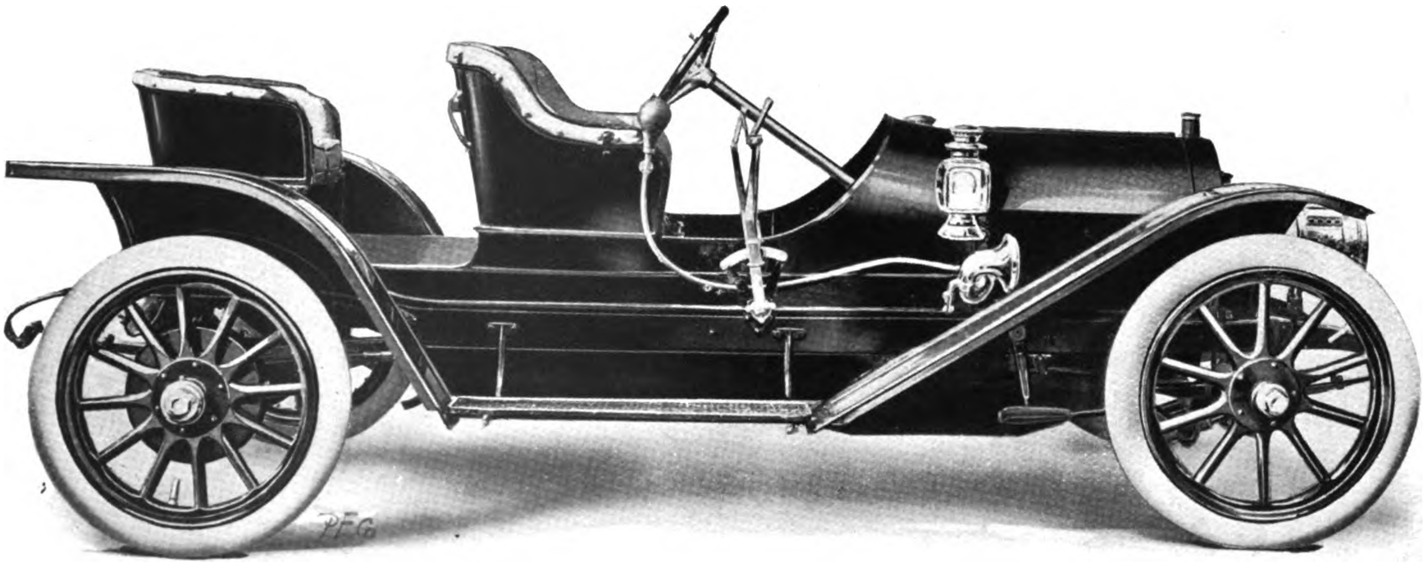
M

Magnetic Spark Plug. A spark plug used in a make-and-break system of ignition in which contact is obtained by means of a magnet.

Magneto. See *Magneto-Electric Generator.*

Magneto-Electric Generator. A machine in which there are no field, magnet coils; the magnetic field of the machine being due to the action of permanent steel magnets. Usually contracted to *magneto.*

Main Plane. In aëronautics, the main supporting surface of a multiplane.



CHALMERS ROADSTER WITH RUMBLE SEAT
The Chalmers Motor Co., Detroit, Mich.

M. A. M. Abbreviation for Association of Motor and Accessory Manufacturers.

Manifold. A main pipe or chamber into which or from which a number of smaller pipes lead to other chambers. See *Intake Manifold* and *Exhaust Manifold.*

Manometer. A device for indicating either the velocity or the pressure of the water in the cooling system of a gasoline motor.

Master Vibrator. A single vibrator which interrupts the current to each of a set of several spark coils in order.

Mean Effective Pressure. The average pressure exerted upon a piston throughout its stroke.

M. E. P. Abbreviation for *mean effective pressure.*

Mercury Rectifier. A mercury vapor converter. See *Converter.*

Mercury Vapor Converter. An apparatus for converting alternating current into direct current by means of a bubble of mercury in a vacuum. The vapor of mercury possesses the property of allowing the flow of current in one direction only. Its principal use is for charging storage batteries.

Misfire. Failure of the mixture to ignite in the cylinder; usually due to poor ignition or poor mixtures.

Mixing Tube. A tubular carbureter for a gas or gasoline engine.

Mixing Valve. A device through which air and gas are admitted to form an explosive mixture. The carbureter of a gasoline engine combines the mixing valve and vaporizer.

Monoplane. An aëroplane having one main supporting surface.

Motocycle. A trade name for a special make of motorcycle.

Motor, Electric. See *Electric Motor.*

Motor, Gasoline. See *Gasoline Engine.*

Motorcycle. A bicycle propelled by a gasoline engine.

Mud-Guard. Metal or leather strips placed over the wheels to catch the flying mud and to prevent the clothing from coming in contact with the wheels when entering and leaving the car.

Muffler Cut-Out. See *Cut-Out, Muffler.*

Muffler Cut-Out Pedal. See *Cut-Out Pedal.*

Muffler, Exhaust. A vessel containing partitions, usually perforated with small holes, and designed to reduce the noise occasioned by the exhaust gases of an engine, by forcing the gases to expand gradually.

Muffler Explosion. Explosion of unburned gases in exhaust passages of the muffler, usually due to poor ignition or poor mixtures.

Multiplane. An aëroplane having two or more supporting surfaces.

Multiple Circuit. A compound circuit in which a number of separate sources or electrically operated devices, or both, have all their positive poles connected to a single positive conductor and all their negative poles to a single negative conductor.

N

N. A. A. M. Abbreviation for National Association of Automobile Manufacturers.

Nacelle. In aëronautics, the framework of an airship.

Naphtha. A product of the distillation of petroleum used to some extent for marine engines.

Negative Pole. That pole of an electric source through which the current is assumed to enter or flow back into the source after having passed through the circuit external to the source.

Non-Deflatable Tire. See *Tire, Non-Puncturable.*

Non-Freezing Solution. See *Anti-Freezing Solution.*

Non-Puncturable Tire. See *Tire, Non-Puncturable.*

Non-Skid Device. See *Anti-Skid Device.*

O

Odometer. An instrument to be attached to an automobile wheel to automatically indicate the distance traveled.

Ohm. Amount of electrical resistance. Such a resistance as would limit the flow of electricity under an electromotive force of one volt to a current of one ampere.

Oil Burner. A burner equipped with an atomizer for breaking up liquid fuel into a spray.

Oil Engine. An internal combustion motor using kerosene or other oil as fuel.

Oil Gauge. A gauge to indicate the flow of oil in the lubricating system.

Oil Gun. A cylinder with a long point and a spring plunger for squirting oil or grease into inaccessible parts of the machine.

Oil Pump. A small force pump providing a constant positive supply of oil under pressure; usually considered to be more reliable than a lubricator.

Oiler. An automatic device for oiling machinery.

Opposed Motor. A gasoline engine whose cylinders are arranged in pairs on opposite sides of the crank shaft, both connecting rods of each pair being connected to the same crank so that the shock of the explosion in one will be balanced by the cushioning effect of the compression in the other. In general these motors are two-cylinder, horizontal.

Ornithopter. A heavier-than-air, or dynamic, flying machine in which flapping wings are used for lifting and propulsion.

Orthogonal. In aëronautics, flapping flight.

Orthopter. Another spelling for *Ornithopter.*

Otto Cycle. See *Four-Stroke Cycle.*

Outside Spark Gap. See *Spark Gap, Outside.*

Overcharged. The state of a storage battery when it has been charged at too high a rate or for too great a length of time.

Overheating. The act of allowing the motor to reach an excessively high temperature due to the heat of combustion being not carried away rapidly enough by the cooling devices, or to insufficient lubrication. Overheating of a bearing is due to insufficient lubrication.

P

Packing. The material introduced between the parts of couplings, joints, or valves, to prevent the leakage of gas or liquids to or from them.

Panel. In aëronautics, a vertical surface.

Panel, Charging. A small switchboard for charging a storage battery.

Parallel Circuit. See *Multiple Circuit.*

Patch, Tire-Repair. Rubber strips for making repairs in punctured or ruptured tires.

Picric Acid. Acid which may be added to gasoline to increase the motor efficiency. Gasoline will absorb about five per cent of its weight of picric acid.

Pilot. In aëronautics, the operator of a flying machine. Strictly, one who is licensed by an aëronautic club.

Pinion. A small gear made to run with a larger gear.

Piston Air Valve. A secondary air valve in the piston of earlier types of gas engine to compensate the imperfect operation of surface carbureters used with those engines and to secure the injection of a sufficient quantity of air to insure the combustion of the charge.

Piston Rings. Rings about the circumference of a piston, whose diameter is slightly greater than that of the piston. These are to insure closer fit and prevent wearing of the piston, as the wear is taken up by the rings which may be easily removed.

Pitch. In aëronautics, the distance forward made by a propeller in one rotation, neglecting the slip.

Plane. In aëronautics, a flat, or approximately flat, surface.

Planetary Gear. An arrangement of spur and annular gears in which the smaller gears revolve around the main shaft as planets revolve around the sun.

Planetary Transmission. A transmission system in which the speed changes are obtained by a set of planetary gears.

Pneumatic Tire. A tire fitted to the wheels of automobiles, consisting usually of two tubes, the outer of india rubber, canvas, and other resilient wear-resisting material, and the inner composed of nearly pure rubber which is inflated with compressed air to maintain the outer tube in its proper form under load.

Polarizing. Formation of gas at the negative element of a cell so as to prevent the action of the battery. This formation of gas is caused by the violent reaction taking place in a circuit of low resistance.

Polyplane. See *Multiplane.*

Poppet Valve. A disk or drop valve usually seating itself through gravitation or by means of springs, and frequently opening by suction or cams.

Port. An opening for the passage of the working fluid in an engine. In aëronautics, the left side of a vehicle or ship.

Portable Garage. See *Garage, Portable.*

Positive Connection. A connection by which positive motion is transmitted by means of a crank, bolt, or key, or other method by which slipping is eliminated.

Positive Motion. Motion transmitted by cranks or other method in which slipping is eliminated.

Positive Pole. The source from which electric current is assumed to flow; the opposite of negative pole. In a magnet, the positive pole is the end of the magnet from which the magnetic flux is assumed to emanate.

Pounding in Engine. Pounding noise at each revolution, usually caused by either tight piston, loose bearing, or premature ignition.

Power Unit. The engine with fuel, cooling, lubrication, and ignition systems, without the transmission or running gears. Sometimes the gear set and driving shaft are included by the term.

Premature Ignition. Ignition of fuel before the proper point in the cycle.

Pressure Gauge. A gauge for indicating the pressure of a fluid confined in a chamber, such as steam in a boiler, etc.

Pressure Lubricator. A lubricating device in which the oil is forced to the bearings by means of a pump or other device for maintaining pressure.

Pressure Regulator. A device for maintaining the pressure of the steam in the principal pipe at a constant point irrespective of the fluctuations of pressure in the boiler.

Primary Coil. A self-induction coil consisting of several turns of wire about an iron core.

Primary Spark Coil. An induction coil which has only a single winding composed of a few layers of insulated copper wire wound on a bundle of soft iron wires, known as the *core.* Also called a *wipe,* or *touch, spark coil.*

Primer. A pin in a float-feed valve so arranged that it may depress the float in priming a gasoline engine. Also called *tickler* and *flushing pin.*

Priming. (1) The carrying of water over with the steam from the boiler to the engine, due to dirty water, irregular evaporation, or forced steaming. (2) Injecting a small amount of gasoline into the cylinder of a gasoline engine to assist in starting.

Progressive Change-Speed Gears. Change-speed gears so arranged that higher speeds are obtained by passing through all the intermediate steps, and *vice versâ.*

Prony Brake. A dynamometer to indicate the horse-power of an engine. A band encircles the flywheel of the engine and is secured to a lever, at the other end of which is a scale to measure the pull.

Propeller Reaction. In aëronautics, the tendency of a single propeller to revolve the vehicle to which it is attached in the opposite direction.

Pterygoid. In aëronautics, a long and narrow wing.

Pump, Air-Feed. See *Air-Feed Pump.*

Pump, Circulation. See *Circulation Pump.*

Pump, Fuel-Feed. A mechanically operated pump for insuring positive feed of fuel to the burner of a steam engine or carbureter of a gas engine.

Pump, Oil. See *Oil Pump.*

Pump, Power Tire. See *Tire Pump.*

Pump, Steam Air-. See *Air-Feed Pump.*

Pump, Steam Boiler-Feed. See *Boiler-Feed Pump.*

Pump, Water Circulating. See *Circulation Pump.*

Puncture. The perforation of an inflated rubber automobile tire by some sharp substance on the roadbed.

Puncture-Closing Compound. A viscous compound placed within the inner tire tube to close the hole caused by a puncture.

Pylon. See *Derrick.*

R

Racing Body. A low, light automobile body, having two seats with backs as low as possible; designed for large fuel capacity and very high speed.

Radiator. A device consisting of a large number of small tubes, through which the heated water from the jacket of the engine passes to be cooled, the heat being conducted from the water by the metal of the radiator and carried away therefrom by air.

Radiator Protector. See *Bumper.*

Radius Rod. A bar in the frame of an automobile to assist in maintaining the proper distance between centers. Also called *distance rod.*

Rawhide Gear. Tooth gears built up of compressed rawhide used for high-speed drive. Sometimes a metal gear is merely faced with rawhide for the purpose of reducing noise.

Reactive Stratum. In aëronautics, the stratum of air which is compressed beneath an aëroplane surface or behind the blade of a propeller.

Recometer. Trade name for special make of odometer and recording speedometer.

Rectifier, Alternating Current. See *Current Rectifier.*

Relief Cock. See *Compression-Relief Cock.*

Removable Rim. See *Demountable Rim.*

Resiliency. That property of a material by virtue of which it springs back or recoils on removal of pressure, as a spring.

Resistance, Electrical. A part of an electric circuit for the purpose of opposing the flow of the current in the circuit. The electrical resistance of a conductor is that quality of a conductor by virtue of which the conductor opposes the passage of electricity through its mass. Its unit is the *ohm.*

Retarding Ignition. See *Ignition, Retarding.*

Retarding the Spark. See *Ignition, Retarding.*

Reverse Cam. On a gasoline engine a cam so arranged that by reversing its motion or shifting it along its shaft it will operate the valves and cause the engine to reverse.

Reverse Gear. In a steam engine, a device by which the valves may be set to effect motion of the car in either direction, In a gasoline automobile, the reversing gear is usually incorporated with the change-speed gears.

Reverse Lever. A lever by which the direction of movement of the driving wheels may be reversed without reversing the engine. This is usually combined with the change-speed levers.

Rheostat. A device for regulating the flow of current in a closed electrical circuit by introducing a series of graduated resistances into the circuit.

Rib. In aëronautics, a part of an aëroplane to give the correct shape to the wing section.

Rim, Removable. See *Demountable Rim.*

Rising Angle. The angle at which an aëroplane ascends

Road Map. A map of a section or locality showing the best roads for motor-car travel, and usually the best stopping places and repair stations.

Roadster. A small motor car designed to be fairly speedy; usually has carrying capacity for an extra-large quantity of fuel and supplies; generally seats two persons, with provision for one or two more, by the attachment of a *rumble* seat in the rear.

Rod, Radius. See *Radius Rod.*

Rod, Steering. See *Steering Rod.*

Roller Bearings. See *Bearings, Roller.*

Roller-Chain. A chain whose links are provided with small rollers to decrease the friction and the noise.

Rudder. In aëronautics, a surface for steering.

Rumble. A small single seat to provide for an extra passenger on a two-seated vehicle; usually detachable.

Runabout. A small two-seated vehicle, usually of a lower power and lower speed, as well as lower operating radius, than a roadster.

Runner. In aëronautics, a part of alighting gear used in place of wheels, and resembling sled runners. Also called *skid.*

Running Gear. The frame, springs, motor, wheels, speed-change gears, axles, and machinery of an automobile, without the body; used synonymously with *chassis.*

S

Safety Plug. See *Fusible Plug.*

Safety Valve. A valve seated on the top of a steam boiler, and loaded so that when the pressure of the steam exceeds a certain point the valve is lifted from the seat and allows the steam to escape.

Saturated Steam. The quality of the steam when no more steam can be made in the closed vessel without raising the temperature or lowering the pressure.

Scavenging. The action of clearing the cylinder of an internal-combustion motor of the burned-out gases.

Screw. An inclined plane wrapped around a cylinder; a cylinder having a helical groove cut in its surface.

Searchlight. A headlight designed to throw a very bright light on the road. Acetylene is usually used as an illuminant, and the lamp has a parabolic reflector and may be turned to throw the light in any direction.

Secondary Battery. See *Accumulator.*

Secondary Circuit. A circuit in which the electromotive force is generated by induction from another circuit in which a variable current is flowing; as the high-tension circuit of a jump-spark ignition system.

Secondary Spark Coil. An induction coil having a double winding upon its core. The inner winding is composed of a few layers of insulated wire of large size, and the outer winding consisting of a great many layers of very small, insulated, copper wire. Also known as a *jump-spark coil.*

Selective Change-Speed Gears. Change-speed gears so arranged that any desired speed combination can be obtained without going through the intermediate steps.

Self-Firing. Ignition of the mixture in a gas engine due to the walls of the cylinder or particles attached to them becoming overheated and incandescent.

Self-Starter. See *Engine Starter.*

Separator, Steam. A device attached to steam pipes to separate entrained water from live steam before it enters the engine, or to separate the oily particles from exhaust steam on its way to the condenser.

Series Circuit. A compound circuit in which the separate sources or the separate electrical receiving devices, or both, are so placed that the current supplied by each, or passed through each, passes successively through the other circuits from the first to the last.

Setting Valves. See *Valve Setting.*

Shaft, Cam. *See Cam Shaft.*

Shaft, Crank. See *Crank Shaft.*

Shaft, Intermediate. The shaft placed between the first and third motion gearing and acting as a carrier of motion between the two.

Shock Absorber. A device attached to the springs or hangers of motor cars to decrease the jars due to rough roads instead of allowing them to be transmitted to the frame of the carriage.

Shock Preventer. See *Shock Absorber.*

Short Circuit. A shunt or by-path of comparatively small resistance around a portion of an electric circuit, by which enough current passes through the new path to virtually cut out the part of the circuit around which it is passed, and prevent it from receiving any appreciable current.

Side-Bar Steering. See *Steering, Side-Bar.*

Side-Slipping. See *Skidding.*

Silencer. See *Muffler, Exhaust.*

Skid. See *Runner.*

Skidding. The tendency of the rear wheels to slide sideways to the direction of travel, owing to the slight adhesion between tires and the surface of the roadbed; also called *side-slipping.*

Skimabout. The name of a particular make of speedy roadster.

Skin Friction. In aëronautics, the friction of the air against surfaces passing through it.

Slip. The distance lost in the travel of a propeller.

Smoke in Exhaust. Smoky appearance in the exhaust due to too rich mixture, low grade of fuel, or faulty ignition.

Soaring, Flight. In aëronautics, gliding flight in an upward direction.

Solid Tire. See *Tire, Solid.*

Sooting of Spark Plug. Fouling of the spark plug with soot, due to poor mixture, impure fuel, or improper lubrication.

Spare Wheel. An extra wheel complete with inflated tire, carried on the car for quick replacement of wheel with damaged tire.

Spark, Advancing. See *Advanced Ignition.*

Spark Coil. A coil or coils of wire for producing a spark at the spark plug. It may be either a secondary or primary spark coil.

Spark Gap. A break in the circuit of a jump-spark ignition system for producing a spark within the cylinder to ignite the charge. The spark gap is at the end of a small plug called the *spark plug.*

Spark Gap, Extra. See *Spark Gap, Outside.*

Spark Gap, Outside. A device to overcome the short circuiting in the spark gap due to fouling and carbon deposits between the points of the high-tension spark plug. It is a form of condenser or capacity in which the air acts as the dielectric between two surfaces at the terminals of a gap in a high-tension circuit.

Spark Intensifier. See *Spark Gap, Outside.*

Spark Lever. See *Timing Lever.*

Spark Plug. The terminals of the secondary circuit of a jump-spark ignition system mounted to leave a spark gap between the terminals projecting inside the cylinder for the purpose of igniting the fuel in the cylinder by means of a spark crossing the gap between them.

Spark Plug, Pocketing. Mounting the spark plug in a recess of the cylinder head to reduce the sooting of the sparking points.

Spark Plug, Sooting of. See *Sooting of Spark Plug.*

Spark Regulator. A mechanism by which the time of ignition of the charge is varied by a small handle on or near the steering wheel.

Spark, Retarding. See *Ignition, Retarding.*

Spark Timer. See *Timer, Ignition.*

Speaking Tube. See *Annunciator.*

Specific Gravity. The weight of a given substance relative to that of an equal bulk of some other substance which is taken as a standard of comparison. Air or hydrogen is the standard for gases, and water is the standard for liquids and solids.

Specific Heat. The capacity of a substance for removing heat as compared with that of another which is taken as a standard. The standard is generally water.

Speed-Change Gear. A device whereby the speed ratio of the engine and driving wheels of the car is varied.

Speed-Change Lever. See *Lever, Change-Speed.*

Speed Indicator. An instrument for showing the velocity of the car.

Splash Lubrication. See *Lubrication, Splash.*

Spontaneous Ignition. See *Self-Firing.*

Sprag. A device to be let down (usually at the rear of the car) to prevent its slipping back when climbing a hill.

Spring. An elastic body, as a steel rod, plate, or coil, used to receive and impart power, regulate motion, or diminish concussion.

Spring Hangers. See *Body Hangers.*

Spring, Lift. See *Anti-Skid Device.*

Spring, Supplementary. See *Shock Absorber.*

Sprocket. A wheel with teeth around the circumference, so shaped that the teeth will fit into the links of a chain which drives or is driven by the sprocket.

Stabilizer. In aëronautics, a surface for automatically maintaining balance.

Starboard. The right-hand side of a ship or vessel.

Starter, Engine. See *Engine Starter.*

Starting Crank. A crank by which the engine may be given several revolutions by hand in order to start it.

Starting Device. (1) In automobiles, an *Engine Starter.* (2) In aëronautics, a device for launching of flying machines.

Starting, Gas Engine. The operation necessary to make the engine automatically continue its cycle of events. It usually consists of opening the throttle, retarding the spark, closing the ignition circuit, and cranking the engine.

Starting Impulse. In aëronautics, the thrust required for starting aëroplanes.

Starting on Spark. In engines having four or more cylinders with well-fitting pistons, it is often possible to start the motor after it has stood idle for some time by simply closing the ignition circuit, provided that the previous stopping of the engine was done by opening the ignition circuit before the throttle was closed, leaving an unexploded charge under compression in one of the cylinders.

Starting Rail. In aëronautics, the rail upon which an aëroplane is run to give the initial velocity necessary for starting.

Starting Truck. A truck upon which an aëroplane is mounted for starting.

Steam. The vapor of water; the hot invisible vapor given off by water at its boiling point.

Steam Boiler. See *Boiler.*

Steam Condenser. See *Condenser.*

Steam, Cycle of. A series of operations of steam forming a closed circuit, a fresh series beginning where another ends; that is, steam is generated in the boilers, passes through the pipes of the engine, doing work successively in its various cylinders, escaping at exhaust pressure to the condenser, where it is converted into water and returned to the boiler, to go through the same operations once more.

Steam Engine. A motor depending for its operation on the latent energy in steam.

Steam Gauge. See *Pressure Gauge.*

Steam Port. See *Admission Port.*

Steering Angle for Front Wheels. Maximum angle of front wheels to the axle when making a turn; should be about 35°.

Steering, Angle of. See *Angle of Steering.*

Steering Check. A device for locking the steering gear so that the direction will not be changed unless desired.

Steering Column. See *Steering Post.*

Steering Gear. The mechanism by which motion is communicated to the front axle of the vehicle, by which the wheels may be turned to guide the car as desired.

Steering Lever. A lever or handle by which the car is guided.

Steering Knuckle. A knuckle connecting the steering rods with the front axle of the motor.

Steering Neck. The vertical spindle carried by the steering yoke. It is the pivot of the bell crank by which the wheel is turned.

Steering Pillar. See *Steering Post.*

Steering Post. The member through which the twist of the steering wheel is transmitted to the steering knuckle. The steering post often carries the spark and throttle levers also.

Steering Rod. The rod which connects the steering gear with the bell cranks or pivot arms, by means of which the motor car is guided.

Steering, Side-Bar. Method of guiding the car by means of an upright bar at the side of the seat.

Steering Wheel. The wheel by which the driver of a motor car guides it.

Steering Yoke. The *Y*-shaped piece in which the front axle terminates. The yoke carries the vertical steering spindle or *steering neck.*

Stephenson-Link Motion. A reversing gear in which the ends of the two eccentric rods are connected by a link or quadrant sliding over a block at the end of the valve spindle.

Storage Battery. See *Accumulator.*

Strainer, Gasoline. A wire netting for preventing impurities entering the gasoline-feed system.

Strangle Tube. The narrowing of the throat of the carbureter just above the air inlets in order to increase the speed of the air, and thus increase the proportion of gas which will be picked up.

Stroke. The distance of travel of a piston from its point of farthest travel at one end of the cylinder to its point of farthest travel at the other end. Two strokes of the piston take place to every revolution of the crank shaft.

Stud Plate. The plate or frame in a planetary transmission system carrying studs upon which the central pinions revolve.

Suction Valve. The type of admission valve on an internal-combustion engine which is opened by the suction of the piston within the cylinder and admits the mixture. The valve is normally held to its seat by a spring.

Sulphating of Battery. The formation of an inactive coating of lead sulphate on the surface of the plates of a storage battery. It is a source of loss in the battery.

Superheated Steam. Steam which has been still further heated after reaching the point of saturation.

Supplementary Surface. In aëronautics, a surface small compared with the main surfaces of an aëroplane for steering or balancing.

Sustaining Surface. In aëronautics, a horizontal surface for the purpose of maintaining a horizontal position; the main plane.

Swivel Joint. The joint for connecting the steering arm of the wheel- or lever-steering mechanism to the arms on the steering wheel. Also called *knuckle joint.*

T

Tachometer. An instrument for indicating the number of revolutions made by a machine in a unit of time.

Tail. In aëronautics, the rear part of a flying machine to improve its stability and afford attachments for rudders and stabilizers.

Tandem Engine. A compound engine having two or more cylinders in a line, one behind the other, and with pistons attached to the same piston rod.

Tangential. In aëronautics, the forward inclination of the lifting force under certain conditions, such that the surfaces tend to advance into the wind.

Tank Gauge. See *Fuel-Level Indicator.*

Tappet Valve. A valve operated by a trip lever, or cam, or some similar device to which it is not positively connected. The valves of gasoline engines are usually of this type.

Taxicab. A public motor-driven vehicle in which the fare is automatically registered by a taximeter.

Taximeter. An instrument in a public vehicle for mechanically indicating the fare charged.

Terminals. The connecting posts of electrical devices; as batteries or coils.

Thermal Unit. Usually called the *British Thermal Unit* or *B. T. U.* A measure of mechanical work equal to the energy required to raise one pound of water one degree Fahrenheit.

Thermostat. An instrument to automatically regulate the temperature.

Thermo-Syphon Cooling. A method of cooling the cylinder of a gas engine. The water rises from the jackets and syphons into a radiator from where it returns to the supply tank, doing away with the necessity for a circulating pump.

Throttle. A valve placed in the admission pipe between the carbureter and the admission valve of the motor to control the speed and power of the motor by varying the supply of the mixture.

Throttling. The act of closing the admission pipe of the engine so that the gas or steam is admitted to the cylinder less rapidly, thus cutting down the speed and power of the engine.

Tickler. A pin in a carbureter arranged to hold down the float in priming. Also called *flushing pin* and *primer.*

Timer, Ignition. An ignition commutator.

Timing Lever. A lever fitted to gas engines by means of which the time of ignition is changed. Also called a *spark lever.*

Timing Valve. In a gas engine using float tube ignition, a valve controlling the opening between the combustion space and the igniter.

Tip, Burner. A small earthen, aluminum, or platinum cover for the end of the burner tube of an acetylene lamp. It is usually provided with two holes, so placed that the jets from them meet and spread out in a fan shape.

Tire, Airless. See *Airless Tire.*

Tire Band. A band to protect or repair a damaged pneumatic tire. See *Tire Protector.*

Tire Case. (1) A leather or metal case for carrying spare tire; same as *Tire Holder.* (2) The outer tube.

Tire Chain. See *Anti-Skid Device.*

Tires, Creeping of. See *Creeping of Tires.*

Tire, Cushion. Vehicle tire having a very thick heavy rubber casing and very small air space. It is non-puncturable and does not have to be inflated, but is not as resilient as a pneumatic tire.

Tire Filling. Material to be introduced into the tire to take the place of air and do away with puncture troubles.

Tire Holder. A metal or leather case for carrying spare tires.

Tire-Inflating Tank. A tank containing compressed air or gas for inflating the tires.

Tire Inflator, Mechanical. A small mechanical pump for inflating pneumatic tires.

Tire, Non-Deflatable. See *Tire, Non-Puncturable.*

Tire, Non-Puncturable. A tire so constructed that it cannot be easily punctured or will not become deflated when punctured.

Tire Patch. See *Patch, Tire Repair.*

Tire-Pressure Gauge. A pressure gauge to indicate the pressure of air in the tire.

Tire Protector. The sleeve or band placed over a tire to protect it from road wear.

Tire Pump. A pump for furnishing air under pressure to the tire; may be either hand- or power-operated.

Tire, Punctures in. Holes or leaks in pneumatic tires caused by foreign substances penetrating the inner tube and allowing the air to escape.

Tire, Single-Tube. A pneumatic tire in which the inner and outer tubes are combined.

Tire Sleeve. A sleeve to protect the injured part of a pneumatic tire. It is a tire protector which covers more of the circumference of the wheel than a tire band. See *Tire Protector.*

Tire, Solid. A tire made of solid, or nearly solid, rubber.

Tire Tape. Adhesive tape used to bind the outer tube to the rim in repairing tires.

Tire Valve. A small valve in the inner tube to allow air to be pumped into the tube without permitting it to escape.

Tonneau. The rear seats of a motor car. Literally, the word means a round tank or water barrel.

Torsion Rod. The shaft that transmits the turning impulse from the change gears to the rear axle. Usually spoken of as the *shaft.*

Touch Spark. See *Wipe Spark.*

Tourabout. A light type of touring car.

Touring Car. A car with no removable rear seats, and a carrying capacity of four to seven persons.

Town Car. A car having the rear seats enclosed but the driver exposed.

Traction. The act of drawing or state of being drawn. The pull (or push) of wheels.

Tractor. A self-propelled vehicle for hauling other vehicles or implements; a traction engine.

Tractor Screw. In aëronautics, a propeller in front of a vehicle.

Transmission Gears. A set of gearing by which power is transmitted. In automobiles, usually called *change-speed gears.*

Transmission, Individual-Clutch. A transmission consisting of a set of spur gears on parallel shafts which are always in mesh, different trains being picked up with a separate clutch for each set.

Transmission, Planetary. A transmission system in which a number of pinions revolve about a central pinion in a manner similar to the revolution of the planets about the sun; usual type consists of a central pinion surrounded by three or more pinions and an internal gear.

Transmission Ratio. The ratio of the speed of the crank shaft to the speed of the transmission shaft or driving shaft.

Transmission, Sliding-Gear. A transmission system in which sliding change-speed gears are used.

Tread. That part of a wheel which comes in contact with the road.

Tread, Detachable. A tire covering to protect the outer tube which may be taken off or replaced.

Trembler. The vibrating spring actuated by the induction coil magnet which rapidly connects and disconnects the primary circuit in connection with jump-spark ignition.

Triplane. An aëroplane having three superposed supporting surfaces.

Truck. (1) A strong, comparatively slow-speed vehicle, designed for transporting heavy loads. (2) A swiveling carriage having small wheels, which may be placed under the wheels of a car.

Try-Cock. A faucet or valve which may be opened by hand to ascertain the height of water in the boiler.

Tube Case. See *Tire Case.*

Tube Ignition. See *Hot-Tube Ignition.*

Tubing, Flexible. See *Flexible Tubing.*

Tubular Radiator. An automobile radiator in which the jacket water circulates in a series of tubes.

Two-Cycle or Two-Stroke-Cycle Engine. An internal combustion engine in which an impulse occurs at the beginning of every revolution, that is, at the beginning of every downward stroke of the piston.

Two-to-One Gear. The system of gearing in a four-cycle gas engine for driving the cam shaft, which must revolve once to every two revolutions of the crank shaft.

U

Under Frame. The main frame of the chassis or running gear of a motor vehicle.

Uniform Pitch. In aëronautics, a changing angle of blade surface from hub to tip of a propeller such that all portions of the propeller blade tend to advance through the air at the same speed.

Universal Joint. A mechanism for endwise connection of two shafts so that rotary motion may be transmitted when one shaft is at an angle with the other. Also called *universal coupling, flexible coupling, cardan joint,* and *Hooke's joint.*

Upkeep. The expenditure for maintenance or expenditure required to keep a vehicle in good condition and repair.

V

Vacuum Line. In an indicator diagram, the line of absolute vacuum. It is at a distance corresponding to 14.7 pounds below the atmospheric line.

Valve. A device in a passage by which the flow of liquids or gases may be permitted or stopped.

Valve, Admission. The valve in the admission pipe of the engine leading from the carbureter to the cylinder by which the supply of fuel may be cut off.

Valve, Automatic. See *Automatic Valve.*

Valve Gear. The mechanism by which the motion of the admission or exhaust valve is controlled.

Valve Grinding. The act of removing marks of corrosion, pitting, etc., from the seats and faces of poppet or disk valves. The surfaces to be ground are rotated in contact with each other, an abrasive having been supplied.

Valve Lifter. A device for raising a poppet valve from its seat.

Valve, Mixing. See *Mixing Valve.*

Valve, Muffler Cut-Out. See *Cut-Out, Muffler.*

Valve Seat. That portion of the engine upon which the valve rests when it is closed.

Valve Setting. The operation of adjusting the valves of an engine so that the events of the cycle occur at the proper time. Also called *valve timing.*

Valve, Suction. An admission valve which is opened by the difference between the pressures in the atmosphere and in the cylinder.

Valve Timing. See *Valve Setting.*

Vaporizer. A device to vaporize the fuel for an oil engine. In starting it is necessary to heat the vaporizer, but the exhaust gases afterwards keep it at the proper temperature. The carbureter of the gas engine properly belongs under the general head of *vaporizer,* but the term has become restricted to the vaporizer for oil engines.

Variable-Speed Device. See *Gear, Change-Speed.*

Vertical Motor. An upright engine whose piston travel is in a vertical plane.

Vertical Rudder. In aëronautics, an upright rudder for horizontal guiding.

Vibrator. The part of the primary circuit of a jump-spark ignition system by which the circuit is rapidly interrupted to give a transformer effect in the coil.

Vibrator, Master. See *Master Vibrator.*

Vis-a-Vis. A horizontal-opposed gas engine.

Volatile. Passing easily from a liquid to a gaseous state; in opposition to *fixed*.

Volatilization. Evaporation of liquids upon exposure to the air at ordinary temperatures.

Volt. Practical unit of electromotive force; such an electromotive force as would cause a current of one ampere to flow through a resistance of one ohm.

Volt-Ammeter. A voltmeter and an ammeter combined; sometimes refers to wattmeter.

Voltmeter. An instrument for measuring the difference of electric potential between the terminals of an electric circuit. It registers the electric pressure in volts.

Vulcanization. The operation of combining sulphur with rubber at a high temperature, either to make it soft, pliable, and elastic, or to harden it.

Vulcanizer. A furnace for the vulcanization of rubber.

W

Water-Cooling. Method of removing the heat of an internal combustion motor from the cylinders by means of a circulation of water between the cylinders and the outer casing.

Water Gauge. An instrument used to indicate the height of water within a boiler or other water system. It consists of a glass tube connected at its upper and lower ends with the water system.

Water Jacket. A casing placed about the cylinder of an internal-combustion engine to permit a current of water to flow around it for cooling purposes.

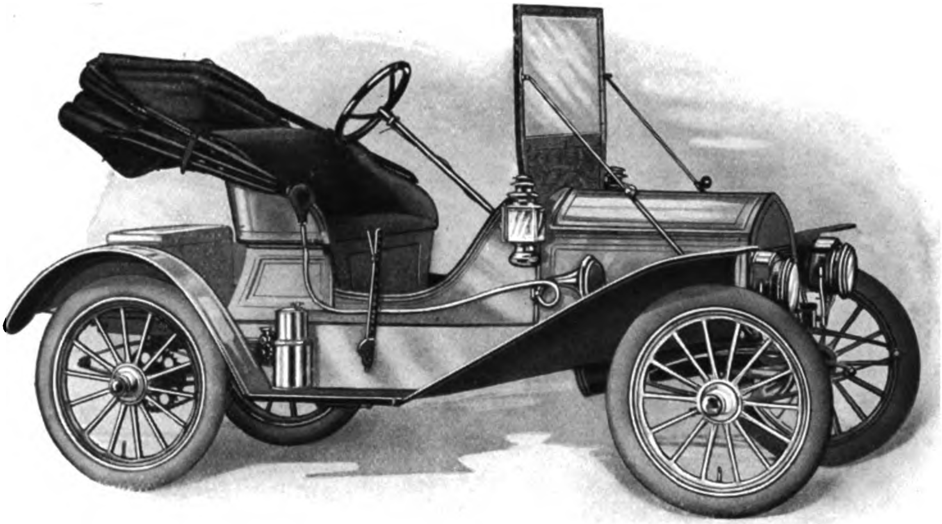
Watt. The unit of electric power. It is the product of the current in amperes flowing in a circuit by the pressure in volts. It is $\frac{1}{746}$ of a horse-power.

Watt-Hour. The unit of electrical energy. The given watt-hour capacity of a battery, for instance, means the ability of a battery to furnish one watt for the given number of hours or the given number of watts for one hour, or a number of watts for a number of hours such that their product will be the given watt-hours.

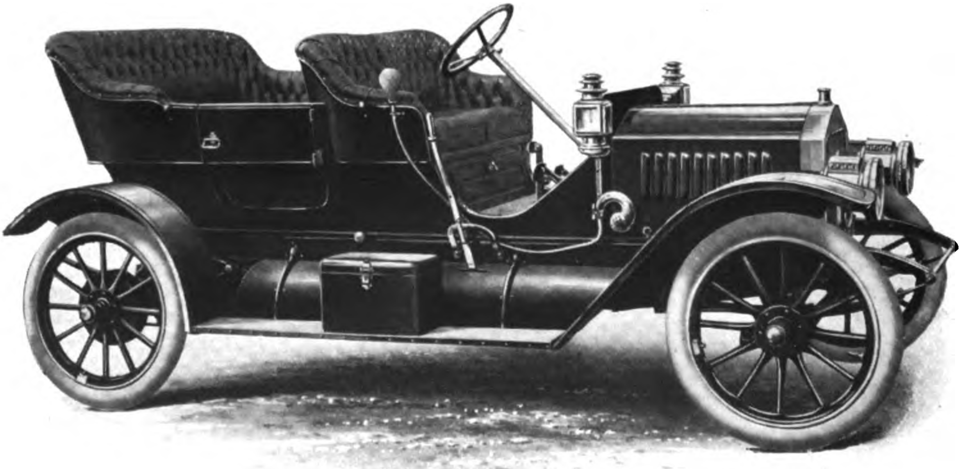
Wheel, Dished. A wheel made concave or convex so that the hub is inside or outside as compared with the rim. This is to counteract the outward inclination of the wheel due to the fact that the spindle is tapered and that its outward center is lower than its inner center.

Wheel, Double-Interacting. The mechanism by which two wheels are hung on one hub or axle, the outer being shod with an ordinary solid tire and the inner with a pneumatic tire so that the weight of the vehicle bears against the lowest point of the pneumatic tire of the inner wheel to give the durability and tractive properties of a solid tire with the resiliency of a pneumatic.

Wheel, Spare. See *Spare Wheel.*



THE METZ 12-HORSE-POWER RUNABOUT
Metz Company, Waltham, Mass.



LAMBERT FLYER. FRICTION DRIVE
Buckeye Mfg. Co., Anderson, Ind.

Wheel Steer. A method of guiding a car by means of a hand wheel.

Wheel, Steering. See *Steering Wheel.*

Wheel, Steering Angle for. The angle which the steering column makes with the horizontal. It varies from 90° to 30° or less.

Wheels, Driving on all Four. The method of using all four wheels of an automobile as the driving wheels.

Wheels, Driving on Front. The method of using the two front wheels as the drivers.

Wheels, Steering on Rear. Method of guiding the vehicle by turning the rear wheels.

Whistle. An automobile accessory consisting of a signalling apparatus giving a loud or harsh sound. Also called a *horn.*

Wind Guard. See *Wind Shield.*

Wind Shield. A glass front placed upright on the dash to protect the occupants of the car from the wind.

Wing Arc. In aëronautics, the length of the arc of movement of a flapping wing.

Wing Skid. In aëronautics, a small skid under the tip of the wing to keep it from contact with the ground.

Wing Wheel. In aëronautics, a small wheel under the end of the wing to keep it from contact with the ground.

Wipe Spark. Form of primary sparking device in which a spark is produced by a moving terminal sliding over another terminal, the break thus made causing a spark. Also called *touch spark.*

Wipe-Spark Coil. A primary spark coil with which the spark is made by wiping contact.

Wire Drawing. The effect of steam passing through a partially closed valve or other constricted opening; so called from the thinness of the indicator diagram.

Working Pressure. The safe working pressure of a boiler, usually estimated as $\frac{1}{6}$ of the pressure at which a boiler will burst.

Worm. A helical screw thread.

Worm and Sector. A worm gear in which the worm wheel is not complete, but is only a sector. Used especially in steering devices.

Worm Gear. The spiral gear in which a worm or screw is used to rotate a wheel.

Worm Wheel. A wheel rotated by a worm.

X

X Spring. A vehicle spring composed of two laminated springs so placed one upon the other that they form the letter *X.*

Y

Yoke, Steering. See *Steering Yoke.*

REVIEW QUESTIONS.

PRACTICAL TEST QUESTIONS.

In the foregoing sections of this Cyclopedia numerous illustrative examples are worked out in detail in order to show the application of the various methods and principles. Accompanying these are samples for practice which will aid the reader in fixing the principles in mind.

In the following pages are given a large number of test questions and problems which afford a valuable means of testing the reader's knowledge of the subjects treated. They will be found excellent practice for those preparing for Civil Service Examinations. In some cases numerical answers are given as a further aid in this work.

REVIEW QUESTIONS

ON THE SUBJECT OF

AUTOMOBILES

PART I

---

1. Describe the various parts and groups of mechanism which are included in the running gear of an automobile.

2. How should frames be constructed so as best to resist the tendency to sag or settle?

3. What is meant by *three-point suspension?*

4. How are springs connected to frames and to axles respectively?

5. What are the two most approved types of construction of front axles?

6. Describe the differences between the *live* and *dead* types of rear axle.

7. Describe the differences between *shaft drive* and *clutch drive* on rear axles. Of what size should rear-axle tubing be?

8. Describe *steering yoke, neck,* and *knuckle.*

9. Describe fully all steering connections between front axle and wheels.

10. Describe fully the screw-and-nut type of steering gear. How does it differ from the worm-and-gear type?

11. What five distinct groups of parts or "systems" are there in the power plant of a gasoline-driven car?

12. Describe the events taking place in each of the four consecutive strokes in a four-cycle gasoline engine.

13. What is meant by *two-cylinder opposed* type of engine construction, and how is this type of engine most advantageously placed in the frame of a car?

14. What is best practice as to materials of construction and methods of manufacture for crank-shafts and cam-shafts respectively?

15. What is the tendency of modern practice in regard to proportioning and action of inlet and exhaust valves?

16. What will be the effect on the running of the engine if valves do not seat properly?

17. What points should be observed in grinding valves?

18. What results if valves are not properly timed?

19. What methods are employed to set valves correctly that are not properly timed?

20. What are some of the causes of poor compression?

21. What various methods are employed for cooling the cylinders of automobile gas engines?

22. What are the differences between the tubular and cellular types of radiators?

23. What are gaskets, and of what materials are they usually made in gas-engine practice?

24. Give some of the signs of overheating, and tell what steps should be taken as soon as overheating is noticed.

25. How should the water-cooling system be cared for in cold weather?

26. Describe briefly the various parts which go to make up the gasoline system.

27. Describe fully what is meant by *high-test* gasoline.

28. Describe fully, with sketch, the *float-feed* type of carbureter.

29. Describe the action of the *compensating* type of carbureter.

30. How can one determine whether he has the proper mixture of gasoline and air?

REVIEW QUESTIONS

ON THE SUBJECT OF

AUTOMOBILES

PART II

---

1. What are some of the conclusions with regard to ignition in gasoline engines that have been reached as a result of many years of experimenting?

2. What regulates the time at which sparking takes place?

3. Explain the action of the vibrator or trembler portion of a spark-coil.

4. How should the vibrator be adjusted so as to give most satisfactory service?

5. Make a sketch of the wiring of an ignition system using dry cells and spark-coil.

6. What are the advantages and disadvantages of shunt-wound direct-current dynamos used for generating electromotive force in ignition systems?

7. How does the magneto differ from the shunt-wound dynamo? What points are in favor of its use in connection with ignition systems?

8. What points should be observed in connection with proper care of magnetos?

9. Specify some requisites of a high-grade spark-coil.

10. Explain the make-and-break system of gasoline-engine ignition.

11. How may we determine which is the positive terminal of an electric line which we wish to use for charging storage batteries?

12. Explain fully how to *advance* or *retard* the spark, and tell what is accomplished by these actions.

13. Explain the action of the throttle-lever.

14. Why should a car not be run with throttle open and spark retarded?

15. What are the objects of the muffler cut-out and compression-relief rods respectively in controlling the engine?

16. Explain the action of constriction-band clutches.

17. How are leather or fiber-faced conical disc clutches constructed and operated?

18. Describe the construction and action of multiple-disc clutches.

19. Describe the construction and action of planetary gears.

20. Describe the construction and action of a sliding transmission gear set.

21. What are the causes of difficulty in changing gears, and of gears grinding?

22. Describe briefly five different types of drive.

23. What are differential gears? Describe their action.

24. Discuss lubrication of (*a*) gas-engine cylinders; (*b*) transmission gears and differentials; (*c*) chains; (*d*) crank-cases and crank-shafts; (*e*) universal joints; (*f*) wheels.

25. Describe the construction and operation of mechanically operated lubricators.

26. Discuss the construction and action of automobile brakes.

27. Describe construction and adjustment of (*a*) cylindrical bearings; (*b*) ball bearings; (*c*) roller bearings; (*d*) annular bearings.

28. What are the first things to be done with a new car?

29. Give seven points to be observed in starting an engine.

30. Give some causes of failure of the engine to start.

REVIEW QUESTIONS

ON THE SUBJECT OF

AUTOMOBILE MECHANISMS

PART I

---

1. What is a cam; what is its function on an automobile engine; and how are cams named?

2. In timing the valves of automobile engines, to what are all angles referred?

3. Give an average set of timing angles.

4. Describe the method of laying out a cam using these angles.

5. Describe the action of the sliding sleeves in the Knight engine; the rotary sleeve in the Ledru engine.

6. Describe and give the action of the surface carbureter, the filtering carbureter, and the spraying carbureter.

7. Trace the passage of air and gasoline through a modern carbureter, using one of the following: Fig. 25, Fig. 26, Fig. 28, Fig. 30, Fig. 43, Fig. 44, or Fig. 48.

8. Mention some of the different types of throttle valves, and the name of the maker using each kind.

9. How does the modern float differ from the earliest form? Describe its action in some one case, as Fig. 28, Fig. 30, or Fig. 42.

10. Give some of the methods of supplying heat to the vaporizing chamber, and the reason for doing this.

11. Give the arguments in favor of and against the auxiliary air valve. Describe the usual form.

12. How many standpipes or fuel nozzles are ordinarily used in carbureters? Mention some makes which use more and the number used in each case.

13. When the engine does not start on the first turn of the crank, what is the prime source of trouble to investigate, and how do you go about it?

14. Tell how to fix a bent float stem; a scored float valve seat; and a punctured metal float.

15. Give all the possible sources of trouble in the inlet pipe.

16. What are the three classes into which self-starting devices are divided?

17. Give one example in each class, and describe its action.

18. What class is most widely used, and why?

19. Describe in detail the Saurer system; the Renault; the Gore.

20. How is the adjustment of wear on valve stems provided for?

21. What are the different kinds of floats made of, and what is the reason for the use of these materials?

22. Give the arguments for and against multiple nozzles for carbureters.

23. What is the most important thing in the fluid-operated starting system, and why?

24. Why is it that many cars will start "on the switch"?

REVIEW QUESTIONS

ON THE SUBJECT OF

AUTOMOBILE MECHANISMS

PART II

---

1. How many different forms of clutches are there? Name them.

2. What is the necessity for a clutch? Give three reasons.

3. Give an essential point in the design of a clutch, considering (*a*) the spring; (*b*) the lining; (*c*) gradual engagement.

4. What are the two specific necessities of a cone clutch, and how does the angularity affect its action?

5. Describe a cone clutch, giving a complete explanation of spring pressure and power transmitted, using the following data: (1) Horse-power 20; speed 1,000 revolutions per min.; average radius of cone 8 in.; coefficient of friction .25; angle of clutch (θ) 12 deg. (2) 1,000 r. p. m.; average radius 7 in.; coefficient of friction .22; cone angle 14 deg.; spring pressure 200 lbs.

6. Mention the name and the maker of a band clutch; describe the clutch, referring particularly to (1) arrangement of band; (2) arrangement of spring; and (3) operating means.

7. Give the formula for the pull necessary to stop a car. What is its value if coefficient of friction is .20, weight of car 2,500 lbs., road wheels 36 in. diameter, and brake drum 14 in. diameter?

8. Mention the name and maker of an expanding band clutch; describe the clutch, referring to (1) spring; (2) band; and (3) operating means.

9. How does the Warner clutch differ from the expanding band? Describe it.

10. Select a true multiple disk clutch, and describe it in detail, referring particularly to (*a*) number of fixed plates and arrange-

ment of plates; (*b*) number of free plates and arrangement of them; (*c*) housing of plates; (*d*) oiling provision; and (*e*) spring.

11. Give in brief the principle of the hydraulic clutch; the magnetic clutch.

12. How many classes of transmissions are there, and what are they? Which one is most used and why?

13. Select one each of the following and describe it fully: progressive transmission; selective three speed; selective four speed; a transmission with all speeds working both ways; individual clutch transmission using disks; and same using internal-external gears.

14. What are the advantages of planetary transmissions? Describe one.

15. What is the main limitation of the planetary gear?

16. Name the advantages of friction driving.

17. Describe the drive using an example with all spurs; one with all bevels; and one with both spurs and bevels.

18. Name and describe an electric driving gear, and give its advantages.

19. Name the forms of gearing used in automobiles.

20. Which form is most used? Which least, and why?

21. What form or forms are selected for quiet running?

22. What item made early worm gears a failure, and later ones successful? What is its usual value?

23. What are the forms of brakes and their subdivisions?

24. Name and describe one each of the principal forms.

25. What is the usual number of brakes fitted (*a*) to a chain-driven car; (*b*) to a shaft-driven car?

26. Design the brake rods, as to diameter of stock, of a car described as follows: weight 2,500 lbs., maximum speed 40 miles per hour, tensile strength of material 50,000 lbs., and factor of safety 6.

27. Figure also the distance in which this would stop the above car; the distance if the speed were increased to 50 miles per hour.

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